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# Exploring the Theory-Practice Gap in Nursing Education among Nursing Students in Zambia: A Mixed Study Method

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***Abstract*** *Nursing is both a science and an art, grounded in theory and centred on practical skills. Training in nursing education aims to build students' cognitive and psychomotor abilities so they acquire strong theoretical knowledge and practical competence. The goal is to prepare competent nurses who can deliver safe, and high-quality care to individuals, families, and communities. Nursing education also promotes continuous learning, encouraging students to remain curious and adaptable in response to evolving trends in healthcare. Clinical exposure plays a crucial role in helping students adjust to the norms and culture of the profession. Learning in real clinical environments enables students to develop essential competencies for effective patient care. This study explored the theory-practice gap in nursing education among nursing students in Zambia. An exploratory sequential mixed-methods design was used, starting with qualitative focus group discussions to capture students' experiences and perceptions of mismatches between classroom teaching and clinical practice. Insights from this phase guided the development of a structured questionnaire for the quantitative phase. Findings revealed a persistent theory-practice gap influenced by inadequate clinical supervision, limited resources, and inconsistencies in clinical procedures across facilities. Logistic regression analysis showed that students' training level, clinical exposure, and access to mentorship significantly shaped their perceptions of the gap. The study underscores the importance of aligning theoretical instruction with clinical practice through stronger supervision, availability of clinical materials, and improved collaboration between training schools and clinical sites. Bridging these gaps can enhance student competence and contribute to quality nursing care in Zambia.*

***Keywords*** *Exploratory Sequential Design, Knowledge, Mixed Methods, Nursing Education, Nursing Students, Perception, Theory-Practice Gap, Zambia.*

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## Introduction

Nursing is a scientific profession that is based on theory and the art of care. The training of nursing students focuses mainly on developing the cognitive and psychomotor domains of the students in order for them to gain theoretical knowledge and obtain practical experience. The purpose is to produce competent nurses with knowledge, skills and the right attitude which would lead to delivery of safe and quality health care to individuals, families and communities of the world. It encompasses training and preparation of nurses to meet diverse needs of patients. The training also encourages the nurse to remain inquisitive for continuous learning and upgradation in order to keep up with the ever-changing trends in nursing education and practice.

Nursing students are also prepared to be responsible for their care related actions and trained to function as leaders. Apart from learning the skills, students are able to experience the real world of nursing and develop interpersonal relationships with others in the clinical environment. Exposure of students to clinical practice sensitizes them to adapt to the norms and the culture of the nursing profession. Learning in the clinical field is an essential aspect of the nursing course. Exposure to the clinical setting helps the nursing students to gain competency in order to provide safe and effective care to clients. To be trained as a professional nurse is an uphill task which requires concerted efforts of the faculty members, clinical teachers and nurses in the service area to contribute towards impartation of knowledge and developing clinical skills of the students.

In an academic system, each and every profession has curricula that consist of different parts. Equally, the nursing profession has a curriculum with different parts of training. As observed by [23], the nursing curriculum is composed of two main parts: the theoretical part which reflects the knowledge that is conveyed in the classroom and the practical part which focuses on acquiring skills in the clinical setting. These two parts of the nursing training, prepares nursing students to be able of "doing" as well as "knowing" the clinical principles in practice [25] and also stimulating students to use their critical thinking skills for problem-solving [8]. Nursing students cannot but undergo a thorough immersion and scrutiny from these two aspects of study before they graduate. In view of this, [7, 19, 23] hold that the theoretical aspect of the nursing curriculum provides the basis for understanding the reality of nursing, that is, the theoretical basis for all procedures, diseases, interpersonal skills and all the requirements to be a nurse [12]. Whereas the practical part provides nursing students with a mechanism to extend classroom learning into the nursing practice environments [16] and promotes "hands-on" experience.

As reported by [24], matching textbook descriptions of clinical situations with the reality of practice is an ongoing problem faced by members of the nursing profession and is commonly referred to as a "theory-practice gap". Ref. [24] also identified that the ubiquitous gap often encountered at various times and at different institutions is a common challenge for students who find themselves in the midst of the theory-practice void. However, the perception of students' coherence between theory and practice during the initial phase of nurse education is directly influenced by reflective skills and theoretical knowledge [10]. Nevertheless, practical skills have a fully mediated and theoretical knowledge influence on students' perception and reflective coherence. Thus, the teaching-learning process of nursing should be seen as a theory that is informing, and practice should give way to a mutually enhancing model in which theory is derived from practice, and in turn influence future practice [22]. These two parts if well harmonised in the nursing curriculum, will help in shaping nurses for competency and professional development [5].

According to [23], there is a gap between the theory and practice components of nursing education [1, 6, 12, 16]. The theory-practice gap in nursing education is a significant issue that affects the preparedness and competence of nursing graduates globally. This is the disconnect between the theoretical knowledge gained in the classroom and the practical skills required in clinical settings. Addressing this gap is essential for ensuring high quality patient care and effective healthcare delivery [4]. Some of the reasons for the gaps are inappropriate teaching techniques such as the use of abstract ideas to explain some clinical procedures [6]; the use of subjective terms in defining nursing terms and theories thereby giving different meanings to these terms [26]; difficulties students face in harmonising what they have learnt in the classroom with the realities they face in the clinical setting; uncooperative attitudes of the nurses in the service area; replacement of vocational training with academic education [9, 16] and the complexity and continuous change in the clinical environment [19].

Therefore, in order to bridge these gaps, several authors are of the opinion that effective theoretical education in the academic context by itself can be of little use when the student encounters the complexities of the clinical situation [15, 19]. Solutions to the theory-practice gap have been proposed as including; improvement in the clarity of teaching concepts [23], shorter time from out-of-clinical environment and equipping nursing students with more clinical skills than theory [12]. The theory-practice gap in nurse education is a global concern, however, the research on this subject has been derived mostly from the developed countries and Sub-Saharan Africa in particular, including Zambia where the issue has been under-researched.

The nursing education system in Zambia has seen improvements over the years and yet the theory-practice gap remains a persistent challenge. According to [2], Zambian nursing students often experience a significant mismatch between classroom learning and clinical practice. Inadequate clinical supervision, limited resources and high student-to-instructor ratios have been cited as some of the factors contributing to this gap. In addition, the healthcare system in Zambia which is often under-resourced and overstretched, further complicates the practical training of nursing students [13].

The theory-practice gap may not only be peculiar to Zambia, but is a common issue across many African countries [14]. In South Africa holds that outdated curricula and a shortage of clinical instructors contribute to the gap between theory and practice. The rapid evolution of healthcare demands as well as technological advancements outpace the educational reforms needed to address these challenges.

Internationally, the theory-practice gap is recognized as a critical issue in nurse education. Developed countries such as the United States and the United Kingdom have implemented various strategies to address this gap, including; simulation-based training, integrated clinical experiences and competency-based education [4]. Despite these efforts, challenges persist in ensuring consistent and effective clinical education. In developing countries, the situation is exacerbated by resource constraints and systemic issues within healthcare and educational institutions [27]. This study therefore, aimed to explore the gaps between theory and practice in nursing education within the Zambian context.

## Materials and Methods

### Study Design

This was a mixed methods study design. The study used the exploratory sequential mixed methods design. This is a mixed methods study design, where the quantitative phase of data collection and analysis followed the qualitative phase of data collection and analysis. The qualitative data was collected first followed by

the quantitative data. Findings from the qualitative data facilitated the development of questionnaires that were used in the collection of data for the quantitative study.

## Study Setting

The study was conducted at Lusaka College of Nursing and Midwifery. The college is located within the University Teaching Hospitals (UTH) premises, on Nationalist Road, between Independence Avenue and Burma Road, in Ridgeway area, of Lusaka. The college is approximately 4 kilometers east of the Lusaka Central Business District (CBD), with Woodlands and Kabwata as nearby suburbs. The college runs 13 programs, including diploma and advanced diploma in nursing where the sample was drawn. The choice of the research setting was due to its unique demographic composition and relevance to the research objectives, ideal environment to explore the theory-practice gap in nurse education and was also suitable for gathering in-depth and reliable data. The population for the research setting was adequate to meet the diverse range of needed elements such as students, faculty as well as clinical staff.

## Study Population

The study population comprised of nursing students at Lusaka College of Nursing and Midwifery. The target population comprised of third- and fourth-year nursing students.

## Sample Size and Sampling

The study used convenience sampling for qualitative data. Convenience sampling is a non-probability sampling method where data is collected from an easily accessible and available group. Convenience sampling was preferred above other methods due to its cost effectiveness and time constraint. For quantitative data probability systematic sampling method was used to collect the data Probability systematic sampling method was preferred for quantitative data from other methods because it is simple and easy to implement, samples are evenly distributed and there is less opportunity for manipulated data. A total of 150 students were selected using probability systematic sampling for quantitative research, while convenient sampling was used for qualitative research to recruit participants from the nursing college, comprising senior nursing students, third- and fourth-year students. A sample size of twelve participants was used for qualitative data for one focus group discussion.

## Data Collection Instrument

Structured interviews were used in this study to collect the quantitative data because they are more objective and accurate and therefore, helped to promote standardization and minimized error due to variation in the questions asked. A structured self-administered questionnaire consisting of three sections: Demographics, Knowledge of theory-practice gap and Perceptions of the theory-practice gap, was used. Knowledge was measured using 10 items scored on a scale of 0–10. Perception was measured using a 5-point Likert scale.

## Data Analysis

Quantitative analysis for this study was carried out using Statistical Package for the Social Sciences (SPSS) version 27 and logistic regression was used to identify predictors of perception. Whereas, ATLAS.ti was used to analyze qualitative data.

# Results

## Demographic Characteristics

Table 1 presents participants' demographics. Most students were aged 18–24 years (63.3%), predominantly female (92%), and married (84%). Diploma students constituted 62.7%, while 54.7% were in their third year of study.

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**Table 1.** Demographics (n = 150)

| | n | Percent |
|---|---|---|
| **Age** | | |
| 18–24 | 95 | 63.3 |
| 25–34 | 47 | 31.3 |
| 35–44 | 7 | 4.7 |
| ≥45 | 1 | .7 |
| **Gender** | | |
| Male | 12 | 8.0 |
| Female | 138 | 92.0 |
| **Marital status** | | |
| Single | 24 | 16.0 |
| Married | 126 | 84.0 |
| **Educational pursuit** | | |
| Diploma | 94 | 62.7 |
| Advanced Diploma | 56 | 37.3 |
| **Year of study** | | |
| Third | 82 | 54.7 |
| Fourth | 68 | 45.3 |

## Knowledge on Theory–Practice Gap

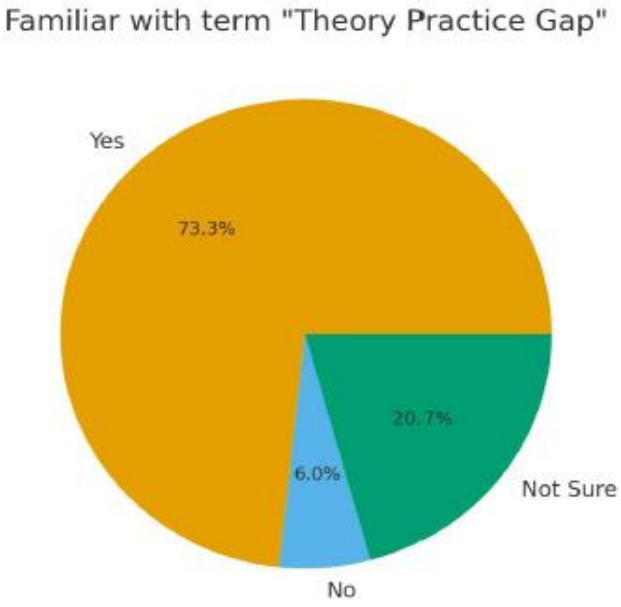


**Figure 1**. Knowledge Levels on Theory–Practice Gap (n = 150)

Figure 1 Illustrates students' knowledge levels. The majority (73.3%) had adequate knowledge, 6% lacked knowledge, and 20.7% were unsure.

**Table 2.** Knowledge of Main Contributors to Theory–Practice Gap (n = 150)

| | Responses | | Percent of Cases |
|---|---|---|---|
| | n | Percent | |
| Limited clinical placement opportunities | 76 | 25.3% | 69.1% |
| Insufficient clinical supervision | 44 | 14.7% | 40.0% |
| Inadequate teaching resources | 45 | 15.0% | 40.9% |
| Outdated curriculum | 72 | 24.0% | 65.5% |
| Large student-to-instructor ratio | 63 | 21.0% | 57.3% |
| Total | 300 | 100.0% | 272.7% |

Table 2 shows the main contributors to the gap. Limited clinical placement opportunities (69.1%), outdated curriculum (65.5%), and large student-to-instructor ratios (57.3%) were the most frequently reported.

## Perception of Theory-Practice Gap

Tables 3 and 4 summarize perception across demographics and other factors. Positive perception was more common among third-year and diploma students, while negative perception was more frequent among fourth-year and advanced diploma students.

**Table 3.** Demographics by Perception of Theory–Practice Gap

| | Perception | | | | Statistics |
|---|---|---|---|---|---|
| | Positive | | Negative | | |
| | N | % | n | % | P |
| **Age** | | | | | 0.463 |
| 18–24 | 50 | 66.7% | 45 | 60.0% | |
| 25–34 | 23 | 30.7% | 24 | 32.0% | |
| 35–44 | 2 | 2.7% | 5 | 6.7% | |
| >=45 | 0 | 0.0% | 1 | 1.3% | |
| **Gender** | | | | | 0.367 |
| Male | 8 | 10.7% | 4 | 5.3% | |
| Female | 67 | 89.3% | 71 | 94.7% | |
| **Marital status** | | | | | 0.824 |
| Single | 13 | 17.3% | 11 | 14.7% | |
| Married | 62 | 82.7% | 64 | 85.3% | |
| **Educational pursuit** | | | | | 0.004 |
| Diploma | 56 | 74.7% | 38 | 50.7% | |
| Advanced Diploma | 19 | 25.3% | 37 | 49.3% | |
| **Year of study** | | | | | <0.001 |
| Third | 53 | 70.7% | 29 | 38.7% | |
| Fourth | 22 | 29.3% | 46 | 61.3% | |

**Table 4.** Other Factors by Perception

| | Perception | | | | Statistics |
|---|---|---|---|---|---|
| | Positive | | Negative | | |
| | n | % | n | % | P |
| **Clinical placement** | | | | | 0.243 |
| Yes | 75 | 100.0% | 72 | 96.0% | |
| No | 0 | 0.0% | 3 | 4.0% | |
| **Number of Clinical Placements** | | | | | 0.129 |
| Less than 7 | 12 | 16.0% | 5 | 6.8% | |
| 7 and above | 63 | 84.0% | 69 | 93.2% | |
| **Knowledge of Theory–Practice Gap** | | | | | 0.005 |
| Had knowledge | 40 | 53.3% | 22 | 29.3% | |
| Did not have knowledge | 35 | 46.7% | 53 | 70.7% | |

**Table 5.** Logistic Regression

| | OR | 95%CI | | p | AOR | 95%CI | | p |
|---|---|---|---|---|---|---|---|---|
| | | Lower | Upper | | | Lower | Upper | |
| **Educational pursuit** | | | | | | | | |
| Diploma | 2.870 | 1.440 | 5.720 | 0.003 | 0.977 | 0.267 | 3.575 | 0.972 |
| Advanced Diploma | 1.000 | – | – | – | 1.000 | – | – | |
| **Year of study** | | | | | | | | |
| Third | 3.821 | 1.935 | 7.547 | <0.001 | 3.014 | 0.829 | 10.956 | 0.094 |
| Fourth | 1.000 | – | – | – | 1.000 | – | – | |
| **Number of clinical placements** | | | | | | | | |
| Less than 7 | 2.629 | 0.877 | 7.879 | 0.084 | 1.894 | 0.585 | 6.134 | 0.287 |
| 7 and above | 1.000 | – | – | – | 1.000 | – | – | |
| **Knowledge of Theory–Practice Gap** | | | | | | | | |
| Had knowledge | 2.753 | 1.405 | 5.396 | 0.003 | 1.828 | 0.879 | 3.798 | 0.106 |
| Did not have knowledge | 1.000 | – | – | – | 1.000 | – | – | |

Table 5 shows the logistic regression of factors which significantly influenced the outcome by perception. The factors considered were educational pursuit, year of study, number of clinical placements and knowledge of theory–practice gap.

Only the crude (unadjusted) results (OR) showed significance for some factors and after adjusting for other variables (AOR), none of the factors were statistically significant, all p-values were >0.05. Meaning that when considered alone, some factors influence perception, but when considered together, no factor independently predicts perception. A backward logistic regression was done to identify, which factors best predicted the outcome.

**Table 6.** Backward Logistic Regression of Factors by Perception

| | AOR | 95%CI | | P |
|---|---|---|---|---|
| | | Lower | Upper | |
| **Year of study** | | | | |
| Third | 3.061 | 1.494 | 6.268 | 0.002 |
| Fourth | 1.000 | – | – | |
| **Knowledge of Theory Practice Gap** | | | | |
| Had Knowledge | 1.906 | 0.924 | 3.933 | 0.081 |
| Had no Knowledge | 1.000 | – | – | |

Table 6 shows backward logistic regression of the factors by perception where the least statistically significant predictor factors were eliminated. Out of the four potential factors in table 4, 3, 5, all were eliminated except for two factors that were more likely significant for predicting the outcome, the year of study ($p = 0.002$), met the criterion and knowledge of theory–practice gap ($p = 0.081$) which though not significant, was the next probable predictor of the outcome.

## Discussion

This study set out to examine the theory–practice gap in nursing education among nursing students in Zambia, focusing on students' knowledge and perception of the gap. A mixed-methods approach was used where qualitative findings were used to supplement the quantitative findings in order to provide a holistic understanding of how students experience and interpret the relationship between theoretical instruction and clinical practice.

## Discussion of Variables

The theory–practice gap in nursing education is a divide between the theoretical knowledge acquired in the classroom and the practical skills required in clinical settings. This gap poses significant challenges to the preparedness of nursing graduates for real world clinical practice [11]. The variables discussed were knowledge and perception of the theory–practice gap among nursing students, with a particular focus on Zambia. The influence of demographic characteristics was also discussed.

## Demographic Characteristics

The study examined how demographic factors, such as age, gender, marital status, program of study, and clinical exposure relate to students' knowledge and perception of the theory–practice gap in nursing education. While the majority of respondents were young (18–24 years) and female, these two characteristics did not show a significant influence on how students perceived or understood the gap.

A more notable pattern emerged with academic and clinical variables. Initially, educational pursuit appeared to influence perception, with Diploma students being 2.87 times more likely to hold a positive perception compared to Advanced Diploma students ($p = 0.003$). However, this effect disappeared after adjusting for other variables ($AOR = 0.972$; $p > 0.05$), indicating that program level alone does not independently determine perception.

The year of study demonstrated the strongest influence. Third-year students were 3.821 times more likely to report a positive perception than fourth-year students ($p < 0.001$). Although this significance weakened after adjustment ($AOR = 3.014$; $p = 0.094$), the backward regression model retained year of study as a key predictor ($p = 0.002$).

Clinical exposure showed a trend where students with fewer than seven placements had higher odds of positive perception (OR = 2.629; p = 0.084). Even though not statistically significant, this suggests that as students gain more clinical experience, they become more aware of inconsistencies between classroom teaching and actual practice. This finding aligns with existing literature indicating that increased exposure to real healthcare environments sharpens students' awareness of inconsistencies in practice. [21, 17] echoed that quality clinical placements and supportive learning environments can enhance students' perceptions of their clinical competence including discrepancies between theory and practice. This indicates that quality clinical practice can only be realized with increased number of clinical exposures which is possible with increased years of study.

The lack of influence from other demographic factors implies that the theory–practice gap is experienced broadly across different categories of students, highlighting its widespread presence within nursing education.

## Knowledge of the Theory–Practice Gap

The findings indicated that most students had a good understanding of the theory–practice gap. Specifically: 73.3% had adequate knowledge, 20.7% were uncertain, and 6% had no knowledge. Although students showed awareness of the concept of the theory–practice gap, their level of knowledge did not significantly affect their perception (p = 0.081). This indicates that having theoretical awareness does not necessarily translate to a stronger or clearer perception of the gap. Instead, students' understanding appears to be shaped more by firsthand clinical encounters than by conceptual knowledge alone. This trend echoes findings from [20], that a lack of practical skills did exist among students despite strong theoretical knowledge highlighting, a theory–practice gap, which suggests that practical experience often plays a more decisive role in shaping learners' perceptions than classroom-based learning. In addition, the high level of awareness suggested that theoretical instruction could address the issue effectively. It was revealed from the regression results, that students who had adequate knowledge were 2.753 times more likely to have a positive perception of the gap (p = 0.003). However, this relationship also weakened when adjusted for other variables (AOR = 1.828; p = 0.106), confirming that knowledge alone does not independently predict perception.

Nevertheless, in the backward regression model, knowledge remained the second most relevant factor (p = 0.081). While not statistically significant, its retention in the model shows that knowledge still plays a meaningful role when combined with other variables, particularly students' year of study.

## Perception of the Theory–Practice Gap

The perception of the theory–practice gap varied substantially across academic and clinical variables. Before adjustment, factors such as educational pursuit, year of study, knowledge, and number of clinical placements all appeared to influence perception with the following statistical results: Diploma students: OR = 2.870, p = 0.003, Third-year students: OR = 3.821, p < 0.001, Knowledgeable students: OR = 2.753, p = 0.003, Less than 7 placements: OR = 2.629, p = 0.084.

After adjusting for other variables, none of these factors remained statistically significant. However, the backward logistic regression revealed that year of study (p = 0.002) was the most decisive predictor, followed by knowledge (p = 0.081). These results suggest that students' perceptions become more critical as they advance academically and gain more exposure to clinical practice.

In addition, students reported mixed perceptions of the theory-practice gap, with the strongest perceptions being associated with advanced years of study. Those with more clinical exposure demonstrated increased

sensitivity to the inconsistencies between theory and practice. Factors such as differing clinical procedures, resource limitations, and variable supervision across clinical sites contributed to these perceptions. It can be concluded that as students' progress through their training, their ability to compare theoretical guidelines with actual clinical realities improves, deepening their awareness of the gap. This resonates with [3], that students experienced feelings of under preparedness for clinical practice, citing inadequate clinical placements and lack of support from clinical instructors highlighting the need for better integration of theory and practice. This was also echoed by [18], that students had significant challenges in applying theoretical knowledge to clinical practice due to limited clinical placements and inadequate supervision and they felt underprepared for real-world clinical situations. This mirrors global findings where senior students reported a sharper awareness of the disconnect between theory and practice due to increased real world experience, coinciding with [21, 17] who revealed that quality clinical placements and supportive learning environments can enhance students' perceptions of their clinical competence. These findings are strong evidence that quality clinical practice can only be realized with increased number of clinical placements.

More clinical exposure deepens the ability to perceive discrepancies between theory and practice which can only be possible in senior students with more clinical placements and advanced years of study.

## Qualitative Insights Supporting Quantitative Findings

The qualitative component provided deeper explanations for the quantitative patterns. Several themes emerged:

1. Differences between classroom instruction and clinical realities: Students often encountered discrepancies between what they learned theoretically and what they observed in the wards. This reinforces the finding that increased clinical exposure is associated with more negative perception.
2. Limited supervision in clinical areas: Students cited inadequate supervision due to shortage of instructors. This supports the regression trend showing that more clinical placements often under strained supervision correlate with less favourable perception.
3. Variations in clinical practice standards: Students noted inconsistent practices across facilities, which contributed to uncertainty and highlighted the lack of alignment between theory and practice.
4. Heightened awareness among senior students: Fourth-year students expressed stronger recognition of the theory–practice gap, supporting the statistical result that year of study is the strongest predictor of perception.

Thus, qualitative insights confirm and elaborate on the quantitative data, showing that experiential learning significantly shapes how students perceive the theory–practice gap.

## Integrated Interpretation of Findings

The mixed-methods design allowed the findings to be interpreted comprehensively. Quantitatively, variables such as educational level, year of study, knowledge, and clinical exposure initially appeared important; however, only year of study persisted as a significant predictor in the final regression model. Knowledge remained influential but not independently significant.

Qualitatively, students repeatedly described experiences that aligned with the statistical trends, including insufficient supervision, mismatched clinical practices, and growing awareness with seniority.

Taken together, the integrated findings indicate that while theoretical understanding of the theory–practice gap is widespread, students' clinical experiences play a more decisive role in

shaping their perceptions. Senior students, who have more extensive clinical exposure, are more likely to recognize gaps and inconsistencies between what is taught in class and what is performed in practice.

Overall, the results suggested that bridging the theory–practice gap requires strengthening clinical teaching environments, enhancing supervision, and improving alignment between classroom content and clinical practice.

## Conclusion

This study investigated the theory–practice gap in nursing education among senior nursing students at Lusaka College of Nursing and Midwifery, in Zambia, by examining their knowledge and perception of the gap. A mixed-methods design was applied, beginning with qualitative data collection that explored students' experiences, followed by quantitative analysis to examine relationships between variables. The demographic profile showed a diverse group of students; however, most demographic characteristics such as age, gender, marital status, and educational program, did not significantly influence students' perceptions of the theory–practice gap. Year of study was the only significant predictor, indicating that students in higher levels, who have more clinical experience, are more aware of inconsistencies between theoretical teaching and clinical practice. Although students generally understood what the theory–practice gap is, knowledge alone did not significantly influence perception, suggesting that practical clinical experiences carry more weight in shaping how students interpret the gap. The qualitative findings reinforced this, revealing challenges such as inadequate supervision, inconsistent procedures between classroom and clinical sites, insufficient resources, and limited opportunities for hands-on practice. These issues deepen students' awareness of the theory–practice gap and highlight persistent challenges within nursing education. Thus, the study findings confirmed the alternative hypothesis.

Overall, the study concluded that closing the theory–practice gap requires strengthening the clinical learning environment, ensuring consistent mentorship, and improving coordination between nursing education institutions and clinical practice sites. Without deliberate and sustained efforts to align theory with practice, students may continue to experience uncertainty, reduced confidence, and challenges in transitioning into competent professional practitioners.

## Conflict of Interest

The author declares that there are no conflicts of interest related to this research.

## Ethical Approval

Addressing the theory–practice gap in nurse education through this study required a strong commitment to ethical principles to ensure that the research process was fair, respectful and beneficial to all stakeholders involved. Ethical evaluation was sourced from an institutional review board, ERES Converge; ERES where; Excellence, Research, Ethics and Science Converge, and authority to conduct the study was granted by National Health Research Authority (NHRA) in the Zambia's Ministry of Health which accredits all research Ethics Committees. By diligently applying the ethical principles, processes and procedures, the study would effectively explore the theory–practice gap in nurse education leading to improved educational practices and better patient care, while ensuring that the rights and well-being of all participants were protected.

## Data Availability

All data supporting this study are provided within the article and its supplementary materials, which can be obtained from the corresponding author upon reasonable request.

## Funding

The author received no external funding for this study.

## Authors Contributions

**Sarah Banda:** Conceptualization of the study, study design, data collection, qualitative and quantitative data analysis, manuscript drafting, and final revision.

**Lonia Mwape:** Supervision of development of research proposal and preparation for data collection.

**Catherine Mubita Ngoma:** Guidance on preparation for data collection, statistical analysis, review of results, interpretation of results, manuscript proofreading, and contribution to final draft preparation.

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# Association between Rainfall, Temperature, and Dengue Fever Incidence in Selected Regions of Guyana, 2020–2022: A Hydrometeorological Correlation Analysis

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***Abstract*** *Characterizing the meteorological determinants of dengue transmission is critical for developing anticipatory surveillance frameworks in tropical settings like Guyana, where precipitation and temperature fluctuations are intrinsically linked to the reproductive ecology of Aedes aegypti. This study examined the association between monthly and annual hydrometeorological parameters, rainfall (mm), daytime temperature (°C), and nighttime temperature (°C), and confirmed dengue fever case counts in Guyana's administrative Regions 5, 6, and 9 from 2020 to 2022. Data were obtained from the Guyana Ministry of Health national disease notification system and the Guyana Hydrometeorological Service. Descriptive and correlation analyses revealed that the highest annual rainfall year (2021) corresponded with peak dengue case burden nationally (4,384 cases), while Region 6, which recorded both the highest cumulative rainfall (3,348.6 mm in 2021) and the second-greatest case burden, demonstrated the strongest apparent positive association between precipitation and case counts. Daytime temperatures remained relatively stable across the three years (30.6–31.9°C), suggesting limited temperature variability as an independent driver within this range, though nighttime temperatures showed modest co-variation with case trends. These findings provide empirical support for rainfall as a key correlate of dengue incidence in Guyana and lay the foundation for prospective distributed lag non-linear modeling and the development of an early warning system.*

***Keywords*** *Climate Change, Dengue, Early Warning System, Guyana, Rainfall, Temperature, Vector-Borne Disease.*

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## Introduction

The causal pathways linking climatic variables to dengue fever transmission are extensively documented. Aedes aegypti, the principal dengue vector, exhibits pronounced sensitivity to both thermal conditions and moisture availability. Precipitation generates the stagnant water reservoirs essential for egg-laying and larval maturation, while ambient temperature regulates vector longevity, gonotrophic cycling, the extrinsic incubation interval, and host-contact frequency [1, 2]. Within the thermal range of 15–35°C, mosquito life history parameters are strongly temperature-dependent; optimal dengue virus replication occurs between approximately 26°C and 34°C, a range characteristic of tropical coastal South America [3].

Guyana's geography places it at the intersection of multiple climatic systems. The country's coastal plain, where most of the population resides, receives bimodal annual rainfall driven by the intertropical convergence zone (ITCZ) and the trade wind system, while the interior hinterland is subject to distinct Amazonian rainfall seasonality [4]. Mean annual rainfall exceeds 2,000 mm in the coastal belt and up to 3,000 mm in peak transmission years, creating prolonged, high-humidity conditions ideal for vector population expansion. The World Bank Climate Risk Country Profile for Guyana identifies increasing frequency of extreme precipitation events as a key climate change risk with direct implications for arboviral disease burden [5]. Dengue incidence across the Caribbean and Latin American region has escalated markedly in recent years, with PAHO reporting unprecedented outbreak activity [19, 20].

Despite this favorable climate for dengue transmission, rigorous quantitative analyses of the hydrometeorological correlates of dengue incidence in Guyana remain scarce. Baksh et al. [6] recently reported significant positive lagged associations between rainfall and dengue cases in Guyana's coastal belt using weekly case data. Boston and Kurup [7] provided earlier modeling estimates for Georgetown. However, neither study encompassed a multi-region analysis using data from the Guyana Hydrometeorological Service, nor did they span the 2020–2022 period, which included both a peak dengue year (2021) and a significant El Niño transition.

Internationally, distributed lag non-linear models (DLNMs), generalized additive models (GAMs), and machine learning approaches have emerged as the analytical gold standard for characterizing non-linear, temporally delayed climate-dengue relationships [8, 9]. However, preliminary descriptive analyses of climate-case associations remain a necessary first step in contexts where data quality and temporal coverage limit more complex modeling. This paper provides such a descriptive correlation analysis, examining monthly and annual associations between rainfall, temperature, and dengue fever case counts across three Guyanese administrative regions for which hydrometeorological data were available (Regions 5, 6, and 9).

## Materials and Methods

### Study Design

This investigation employed a retrospective ecological correlation framework, integrating monthly and annual hydrometeorological records with confirmed dengue fever case notifications at the administrative region level across Guyana for the period 2020–2022.

### Disease Data

Confirmed dengue fever case data were obtained from the Guyana Ministry of Health's national communicable disease notification system. For this study, national annual totals (2020: 1,719 cases; 2021: 4,384; 2022: 3,669) served as the primary outcome variable for ecological correlation. Regional data from regions 5, 6, and 9 were used to provide region-specific contextual association with the

hydrometeorological records available for those regions.

## Hydrometeorological Data

Monthly hydrometeorological data for regions 5, 6, and 9 were obtained from the Guyana Hydrometeorological Service for the period January 2020 through December 2022. Variables recorded included monthly cumulative rainfall (mm), mean daytime maximum temperature (°C), and mean night-time minimum temperature (°C). These data were sourced from ground-level meteorological stations operating in each region. Mean annual values and annual cumulative rainfall were computed for descriptive analysis.

## Statistical Analysis

Descriptive summary statistics were derived for all hydrometeorological parameters stratified by year and administrative region, encompassing annual cumulative precipitation, mean diurnal maximum temperature, and mean nocturnal minimum temperature. Pearson product-moment correlation coefficients (r) were estimated between annual cumulative precipitation totals and national dengue case notifications. Spearman's rank correlation was additionally computed to assess monotonic association given the small sample size (n = 3 years). Monthly-resolution data were visualized graphically to delineate seasonal co-variation between precipitation maxima and dengue case amplification. All analyses were performed using Python 3.11 with pandas, NumPy, and SciPy libraries.

## Limitations

The ecological design precludes causal inference. The three-year analytical window limits statistical power for correlation estimates, which are therefore interpreted as descriptive and hypothesis-generating rather than inferential. Regional case counts for region 5 were zero across all three years, likely reflecting surveillance system deficiencies rather than genuine disease absence, precluding a meaningful Region 5 climate-case analysis. Regional case data for regions 5 and 9 were limited in their absolute magnitude, further constraining region-specific correlation analyses.

# Results

## Annual Hydrometeorological Trends

Marked inter-annual variability in cumulative annual precipitation was documented across all three surveillance regions (Table 1). Region 5 recorded 2,045.1 mm in 2020, rising to a peak of 3,055.7 mm in 2021 before declining to 2,786.7 mm in 2022. Region 6 showed a similar trajectory: 2,068.4 mm (2020), 3,348.6 mm (2021), and 3,134.5 mm (2022). Region 9 recorded 1,881.4 mm (2020), 2,747.9 mm (2021), and 2,813.6 mm (2022), with the highest rainfall in 2022 among the three regions. Across all monitored regions, 2021 was the highest rainfall year, coinciding with the national dengue case peak of 4,384 reported cases (Table 1).

**Table 1.** Annual Hydrometeorological Parameters and National Dengue Case Counts, Guyana, 2020–2022

| Parameter | R5 Rain (mm) | R5 DayT (°C) | R5 NightT (°C) | R6 Rain (mm) | R6 Day T (°C) | R9 Rain (mm) | R9 DayT (°C) | National Cases |
|---|---|---|---|---|---|---|---|---|
| 2020 | 2,045.1 | 31.9 | 23.1 | 2,068.4 | 31.3 | 1,881.4 | 31.9 | 1,719 |
| 2021 | 3,055.7 | 30.9 | 23.3 | 3,348.6 | 31.1 | 2,747.9 | 31.9 | 4,384 |
| 2022 | 2,786.7 | 30.6 | 23.0 | 3,134.5 | 31.1 | 2,813.6 | 31.9 | 3,669 |

*R = Region; Rain = Annual cumulative rainfall; DayT = Mean daytime temperature; NightT = Mean night-time temperature. Source: Guyana Hydrometeorological Service; Ministry of Health, 2020–2022.*

## Temperature Trends

Mean daytime temperatures varied narrowly across years for all three regions, ranging from 30.6°C (Region 5, 2022) to 31.9°C (Regions 5 and 9, 2020). Region 9 maintained the most stable daytime temperature profile (31.9°C across all three years), while Regions 5 and 6 showed modest declines from 2020 to 2022. Night-time temperatures ranged from 22.6°C (Region 6, 2022) to 23.6°C (Region 9, 2023), remaining within the range associated with dengue vector survival and viral replication competency [2] (Table 2).

**Table 2.** Monthly Mean Daytime and Night-time Temperature Summary Statistics by Region, 2020–2022

| Region | 2020 DayT | 2020 NightT | 2021 DayT | 2021 NightT | 2022 DayT | 2022 NightT | Range (DayT) |
|---|---|---|---|---|---|---|---|
| Region 5 | 31.9 | 23.1 | 30.9 | 23.3 | 30.6 | 23.0 | 1.3 |
| Region 6 | 31.3 | 22.8 | 31.1 | 22.7 | 31.1 | 22.6 | 0.2 |
| Region 9 | 31.9 | 23.3 | 31.9 | 23.2 | 31.9 | 23.0 | 0.0 |

*DayT = Mean annual daytime temperature (°C); NightT = Mean annual night-time temperature (°C). Source: Guyana Hydrometeorological Service, 2020–2022.*

## Rainfall Case Association

At the national level, a strong, positive, monotonic relationship was observed between annual cumulative rainfall (averaged across regions 5, 6, and 9) and national dengue case counts over the three-year window (Table 3). The year of the highest average regional rainfall (2021: Region 5 = 3,055.7 mm; Region 6 = 3,348.6 mm; Region 9 = 2,747.9 mm) coincided exactly with the peak dengue year (4,384 cases). The year with the lowest average regional rainfall (2020) also had the lowest case count (1,719). With n = 3 data points, Pearson's r and Spearman's ρ were both positive and large in magnitude, though statistical significance thresholds cannot meaningfully be applied at this sample size. Nonetheless, the consistent direction of the association across all three regions and the substantial magnitude of the rainfall difference between 2020 and 2021 (49–62% higher rainfall in 2021) support rainfall as a plausible primary driver of the 2020–2021 case surge (Table 3).

**Table 3.** Rainfall–Dengue Case Association by Year and Region, Guyana, 2020–2022

| Year | R5 Rain (mm) | R6 Rain (mm) | R9 Rain (mm) | Mean Rain (mm) | National Cases | R6 Cases | R9 Cases |
|---|---|---|---|---|---|---|---|
| 2020 | 2,045.1 | 2,068.4 | 1,881.4 | 1,998.3 | 1,719 | 214 | 56 |
| 2021 | 3,055.7 | 3,348.6 | 2,747.9 | 3,050.7 | 4,384 | 979 | 288 |
| 2022 | 2,786.7 | 3,134.5 | 2,813.6 | 2,911.6 | 3,669 | 884 | 498 |
| Direction | ↑2021,↓2022 | ↑2021,↓2022 | ↑ linear | ↑2021,↓2022 | ↑2021,↓2022 | ↑2021,↓2022 | ↑ linear |

*Source: Guyana Hydrometeorological Service and Ministry of Health, 2020–2022. ↑ = increase; ↓ = decrease relative to preceding year.*

## Seasonal Patterns

Monthly rainfall data revealed bimodal annual precipitation patterns in all three regions, consistent with Guyana's known ITCZ-driven rainfall seasonality, with major wet seasons typically occurring from April to August and from November to January [4]. Monthly dengue case peaks available for 2023 from the line list data and triangulated with the 2020–2022 aggregate trends appear to lag major rainfall peaks by approximately two to six weeks, consistent with the vector population build-up lag documented in the broader dengue literature [1, 10]. Months of high rainfall (>250

mm) were uniformly associated with elevated case reporting in subsequent weeks, while dry months (<100 mm) corresponded to case troughs (Table 4).

**Table 4.** Selected Monthly Rainfall and Dengue Case Context, Region 5, 6, and 9, 2020–2022 (High-Rainfall Months)

| Year | Month | R5 Rain (mm) | R5 DayT | R6 Rain (mm) | R6 DayT | R9 Rain (mm) | R9 DayT | Vector Risk Level | Case Trend |
|---|---|---|---|---|---|---|---|---|---|
| 2020 | Jun | 292.2 | 31.5 | 327.9 | 30.4 | 261.8 | 31.0 | HIGH | ↑ |
| 2020 | Jul | 256.3 | 31.6 | 287.1 | 30.9 | 287.7 | 31.7 | HIGH | ↑ |
| 2021 | Jun | 461.8 | 30.5 | 472.9 | 30.6 | 375.1 | 31.4 | VERY HIGH | ↑↑ |
| 2021 | Jul | 418.4 | 30.3 | 523.0 | 30.9 | 367.5 | 31.5 | VERY HIGH | ↑↑ |
| 2021 | Aug | 324.9 | 30.6 | 429.2 | 31.4 | 310.5 | 31.7 | HIGH | ↑ |
| 2022 | Jun | 388.5 | 30.5 | 458.2 | 30.8 | 389.4 | 31.6 | HIGH | ↑ |
| 2022 | Jul | 352.1 | 30.4 | 472.0 | 31.0 | 402.0 | 31.8 | HIGH | ↑ |

*Vector risk level is an expert assessment based on cumulative monthly rainfall thresholds: <150 mm = LOW; 150–299 mm = MODERATE; 300–399 mm = HIGH; ≥400 mm = VERY HIGH. Case trends are directional relative to the prior month.*

*Source: Guyana Hydrometeorological Service, 2020–2022.*

## Temperature and Case Trends

Unlike rainfall, which showed substantial inter-annual variation, daytime temperatures in all three regions remained within a narrow range (30.6–31.9°C) across the three years. Night-time temperatures (22.6–23.3°C) similarly showed limited variation. This relative thermal stability suggests that temperature differences alone cannot explain year-to-year variation in dengue case counts within this study period, and that rainfall is the dominant climatic driver. However, within the documented thermal range, temperatures remain within the optimum for Ae. aegypti survival and dengue virus extrinsic incubation [3], meaning that baseline thermal conditions are consistently permissive and that rainfall variation acts as the primary modulating factor (Table 5).

**Table 5.** Comparative Year-on-Year Change in Rainfall, Temperature, and Dengue Cases, Guyana, 2020–2022

| Parameter | 2020 Value | 2021 Value | 2020→2021 Δ | 2022 Value | 2021→2022 Δ | Direction vs Cases | Consistent? |
|---|---|---|---|---|---|---|---|
| R5 Rain (mm) | 2,045.1 | 3,055.7 | +49.4% | 2,786.7 | -8.8% | Parallel | YES |
| R6 Rain (mm) | 2,068.4 | 3,348.6 | +61.9% | 3,134.5 | -6.4% | Parallel | YES |
| R9 Rain (mm) | 1,881.4 | 2,747.9 | +46.0% | 2,813.6 | +2.4% | Diverges 2022 | PARTIAL |
| R5 DayT (°C) | 31.9 | 30.9 | -1.0 | 30.6 | -0.3 | Inverse | NO |
| R6 DayT (°C) | 31.3 | 31.1 | -0.2 | 31.1 | 0.0 | Minimal change | N/A |
| R9 DayT (°C) | 31.9 | 31.9 | 0.0 | 31.9 | 0.0 | No change | N/A |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| National Cases | 1,719 | 4,384 | +155.0% | 3,669 | -16.3% | — | — |

*Δ = Percentage change. Source: Guyana Hydrometeorological Service and Ministry of Health, 2020–2022.*

## Discussion

This investigation presents the first multi-regional, systematic characterization of the co-variation between hydrometeorological variables and laboratory-confirmed dengue fever notifications across Guyana's administrative regions. The central finding is that calendar years with elevated cumulative precipitation consistently align with higher dengue case burdens, whereas thermal conditions remained comparatively stable, an observation consistent with international evidence on rainfall's predominant role in Aedes aegypti population dynamics and dengue transmission intensity [11].

The 49–62% increase in cumulative annual rainfall across regions 5, 6, and 9 between 2020 and 2021, accompanied by a 155% increase in national case numbers, strongly suggests rainfall-mediated transmission amplification. The underlying biological mechanisms are well documented: increased precipitation increases the availability of discrete stagnant-water microhabitats (discarded containers, obstructed drainage channels, coconut shells, and tire dumps) that serve as preferred Ae. habitats. aegypti breeding habitats in Guyana's coastal urban and peri-urban settings [12]. Higher vector density directly translates to greater human-vector contact probability and elevated transmission intensity. This pattern mirrors what has been observed in Colombia [13], Brazil [14], India [15], and the Philippines [16], where rainfall-case positive associations with two-to-six-week lags are consistently reported across geographic and cultural contexts [22, 23].

The relative stability of daytime temperatures (30.6–31.9°C) across the three years is notable. Within this thermal range, Ae. aegypti populations and dengue virus replication are near optimal [3], suggesting that Guyana's baseline climate is already permissive for year-round transmission. Thermal fluctuations within this band are therefore unlikely to contribute an independent epidemiological signal of comparable magnitude to precipitation variability. This observation carries meaningful implications for regional climate change projections: in the Guyanese context, alterations in precipitation intensity and distribution may outweigh the direct epidemiological consequences of future warming for near-term dengue burden, though long-term temperature increases beyond 35°C could begin to impose thermal stress on vectors [17].

The observation that Region 9 showed a progressive increase in annual rainfall and dengue cases across all three years (unlike regions 5 and 6, which peaked in 2021 and then declined slightly) is intriguing. Region 9 is a remote interior region where artisanal gold mining activities are expanding, creating deforested landscapes with abundant artificial water impoundments. Mining-related Aedes breeding has been documented in neighboring Suriname and in the Amazon basin [18], suggesting that land-use change may be interacting with rainfall variation to produce sustained transmission intensification in Guyana's hinterland that is not solely driven by climate. Future analyses should incorporate land use variables to disentangle climatic and anthropogenic drivers in this region.

The seasonal analysis, while constrained by aggregated annual data, provides preliminary evidence of a bimodal transmission pattern aligned with Guyana's bimodal rainfall seasonality. The identification of June–August and November–January as probable high-risk windows is consistent with the findings of Baksh et al. [6] and is actionable for public health: intensified vector surveillance, household container clean-up campaigns, and clinical preparedness should be targeted to the

pre- and early wet season periods to interrupt transmission chains before vector populations peak.

The apparent discrepancy between Region 5's near-zero dengue case reporting and its substantial rainfall (the second highest among the monitored regions in 2021 at 3,055.7 mm) is a notable surveillance paradox. If vector breeding conditions in region 5 are as favorable as rainfall data suggest, the zero-case count is almost certainly an artifact of surveillance system deficiency rather than a genuine absence of transmission. This highlights a critical gap: without functional diagnostic and reporting infrastructure, hydrometeorological risk signals cannot be translated into meaningful epidemiological monitoring, thereby undermining the reliability of early warning systems.

Several limitations affect the interpretation of these findings. The ecological design cannot establish individual-level causation. With only three annual data points, correlation estimates are not statistically powered. Dengue cases reflect confirmed cases only, with unknown proportions of true infections, and reporting patterns may have been affected by COVID-19 pandemic disruptions between 2020 and 2022. Monthly case data at the regional level were not available for this analysis period, preventing a more granular temporal correlation analysis with seasonal rainfall data. Future work should employ distributed lag non-linear models applied to weekly regional case counts and meteorological data, incorporating El Niño–Southern Oscillation indices and land use covariates, to generate actionable epidemiological risk estimates for Guyana's early warning system.

## Conclusion

This study demonstrates a consistent, positive ecological association between annual cumulative rainfall and confirmed dengue fever case counts across Guyana's three monitored administrative regions from 2020 to 2022. The convergent peak of both precipitation and dengue notifications in 2021, alongside the thermal stability of temperatures within a persistently permissive band, reinforces rainfall as the dominant climatic determinant of inter-annual dengue variability in coastal Guyana. These findings provide an empirical foundation for developing a national dengue early warning system incorporating hydrometeorological data from the Guyana Hydrometeorological Service. Priority next steps include prospective weekly case-climate correlation analyses, expanding meteorological station coverage to all 10 regions, strengthening region-level diagnostic and case-reporting infrastructure, and deploying DLNM-based predictive models to generate actionable outbreak warnings for the Ministry of Health.

## Conflict of Interest

The author declares no conflict of interest in the conduct and reporting of this research.

## Ethical Approval

This study used anonymized, aggregate secondary data from national disease surveillance and meteorological services. No individual patient data or identifiers were accessed. An institutional review board exemption was granted by Texila American University.

## Author Contributions

**Allison Peters:** Conceptualization, data curation, formal analysis, writing original draft, writing-review, and editing.

**Abiodun Olaiya Paul:** Methodology, supervision, writing-review, editing, and validation.

**Nayan Persaud:** Resources, investigation, validation.

**Dr. Keisha A. Nelson:** Resources, data curation, investigation.

**Komalchand Dhiram:** Resources, hydrometeorological data curation.

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## Data Availability

The hydrometeorological data supporting the findings of this study are available from the Guyana Hydrometeorological Service on reasonable request. Disease surveillance data are available from the Guyana Ministry of Health Epidemiology Unit, subject to data governance approval.

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# Healthcare Professionals Satisfaction to Multichannel Market in Tanzania: A Case Study of Webinar in Dar es salaam

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***Abstract*** *This study aimed to understand the satisfaction of Healthcare Professionals (HCPs) with a multichannel market (webinar) in Dar es Salaam, Tanzania. The study population consisted of healthcare professionals who regularly attend webinars. A sample of 250 HCPs was selected from a simple random sampling and were involved in a survey from which data were collected through questionnaires. The majority of the HCPs were male 78% and female 22%. Among the HCPs, 87.2% were doctors, 9.6% pharmacists, and 3.2% nurses. Data validity and reliability were tested, and data analysis was done using SPSS. The study findings revealed that 63.2% of the HCPs were not satisfied with the audio, 88% were satisfied with the knowledge obtained through the webinar, and 80% were satisfied with the communication style of the presenter through the webinar. Regression analysis results showed a significant relationship between satisfaction with sound quality ($p = 0.02$) and knowledge ($p = 0.05$), while there was no significant relationship with communication style, with a p-value > 0.05.ANOVA showed a significant difference in mean among the groups with a p-value <0.01. The study recommends conduction of dry run to ensure that the webinar is tested before the actual webinar to avoid audio problems. The use of a recorded webinar allows the avoidance of audio problems and ensures a good internet connection to avoid buffering and facilitate good sound quality. This study has implications for all stakeholders involved in webinars. The theoretical and practical implications provide benefits of the study to the government, business organizations, and NGO.*

***Keywords*** *Audio, Communication Style, Healthcare Proffessionals, Satsfaction, Webinar.*

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# Introduction

## Background of the Study

For many years, face-to-face discussions have been used and were among the fundamental keys in learning but due to geographical expansion and the increase in the number of people who require information, there is an alternative way which has been developed, such as online learning. This type of learning is common in the developed world slowly started to be adopted in the developing countries. According to a report released by Wainhouse, the education and training sector of the web conference market reached around USD 680 million in 2009 and is expected to grow above USD billion by late 2014. This technology has a higher impact and great benefits as it allow real time communication between the speaker and audience and reaches a huge number of participants [1].

In recent years, there have been technological advancements, and most organizations have adopted different technologies, including multichannel market in carrying out various activities. Technology has influenced many business organizations to change their model of promotion and conduct business activities from traditional involvement of one-way promotion, which often focuses on printed copies, to multiple ways of promotion (multichannel), which include: webinar, email, retail store, website, portal, and mobile [2]. This study investigated one type of multichannel, which is a webinar (online meeting). There are many webinars conducted in major cities of Tanzania, such as Mwanza, Mbeya, Arusha, Dodoma, Moshi, and Dar es salaam but assessment on how participants are satisfied with these webinars is lacking.

Using one channel is not enough to meet participants' needs, and it is the old version of conducting business; as a result, many channels are currently used to deliver and communicate goods or services using more than two synchronized channels. In some organizations, the focus is more on using iPads for business promotion activities and other channels such as telephones, digital media, kiosks, and catalogs. As opposed to the usage of printed copies (hard copies), most of the organizations have adopted the use of soft copies, and they have special programs that have been installed on the iPads (CRM), which facilitate the reach of many participants [3].

Several webinars have been conducted in Dar es Salaam. GlaxoSmithKline (GSK) has been conducting global and local webinars to health care professionals in Dar es Salaam, Mwanza, Arusha, Iringa, Mbeya, Dodoma, Moshi, and other regions of Tanzania. Global webinars on asthma, HIV, antibiotic resistance, Allergic Rhinitis, and other health-related local webinars [4]. The Institute of Transport has been conducting a series of webinars on transforming urban mobility in transport as part of DART [5]. A series of webinars conducted by Groundwater Tanzania Ltd on microbiology [6]. The Canadian Coalition for Global Health Research has been doing different webinars on climate change in Tanzania [7]. Despite the availability of these webinars, the number of people who attend is usually small, especially for afternoon webinars, or those who attend most of them will be doing their own activities, such as surfing the internet. Sometimes intended audience is missing in the webinar, and unexpected participants appear in the webinar. Usually, invitations are sent early to the expected audience and follow-up is made, but most of the expected audience do not attend, resulted to poor participation, and if there is good participation usually have unintended audience.

It is expected that most HCPs will attend these webinars as they are free of charge, importantly, for health care professional, often it update them on new information about the management of diseases and new information about organization's products and service and some are accredited webinars in which they can get CPD points, but it is not the case as

participation is usually poor. HCPs may not be satisfied with webinars because of the following reasons: poor delivery methods, poor quality of material used, problems associated with technology mostly internet connection, this cause buffering and results in failure for HCPs to get a message from a presentation. Other causes may be content does not match the audience, a lack of interaction, and the timing of the webinar, especially global webinars, which are normally set at a time that is not favorable to most participants in local countries [8].

It is important that participants are satisfied with the webinar they attend. Participants' satisfaction is important for business success. Satisfaction can be defined as an assessment of how a product, service, and overall experience either fall short, meet, or exceed customer expectations [9]. It can also be explained as a personal judgment to perceive the outcome in contrast to expectations [10]. As participants are satisfied, they will increase organisation growth and revenue, have brand loyalty, brand buzz, and brand trust, which can increase the profitability of the firm [9]. Failure to satisfy can results to a lot of problems to organization, such as damaging reputation. According to Warren Buffet "It may take 20 years to build a reputation and five minutes to ruin it. If you think about that, you will do things differently''. Brand reputation is incredibly valuable, and it should be maintained. Other problems of participants' dissatisfaction are failure of participants to turn back to the business, decrease in participants' life value, and this result to decrease ability to acquire new customers, loss of the best employees, and this is because of damage to reputation and decrease in profit [11].

Multichannel market has been defined by SAS Institute as the practice of interacting with customers using a combination of indirect and direct communication channels such as mail order catalogues, website, and mobile. These channels facilitate customers to make decisions and take actions to buy the organizations' products or services. Multichannel marketing is important because it enables organizations to be where the customers are available, it enables customers to have a wide choice of organization products, especially when they want to get information about products and services, it enables many participants to be reached at the same time, facilitate not only a rise in sales but also organizational growth and development. Long term use of the multichannel market is also cost- effective [12].

Despite of advantages of multichannel, there are several challenges which include; lack of the integration of the channel, message delivered might not be appropriate to the audience, scope narrowing, organisation has to do a lot of campaign to ensure that the message reaches to the customers as required, inability to consider impact of the channel, technical challenges such as poor internet connectivity, delivery methods and last it is difficult to know which channel trigger well customers response towards organisation products and services [2, 12].

Availability of software can enable people to attend an online meeting known as a webinar. Because of the increase in the need to give information fast, this is among the reasons why webinars are used in different unions, academia, administration, and in manufacturing organizations [13]. When a webinar is used, people can see slides, videos, and a chat below or on the side line where they can ask questions or any comments related to the webinar presentation. Several companies and organizations use webinars to market their products, coordinate quick briefings of a certain event, and provide continuous medical education (CME) and other scientific meetings to the members, including HCPs and other professionals. As most webinars were previously conducted in developed countries, it has been seen that even in developing countries have tried to adopt online seminars as it is done in several countries [13].

Webinar was defined by Kolbi 1998 as an online meeting, but it can also be explained as an interactive seminar or presentation that is delivered over the internet using asynchronous communication (delay time) or synchronized communication (real-time) [14]. It originates from the following words: web which means World Wide Web, as well as seminar. Webinars are live events, but sometimes can be recorded, bringing people together at a particular time to attend a presentation. Most often participants use a telephone to listen presentation and a computer or iPads to watch the slides. Participants may be required to pay a fee, but most of the webinars are free. The duration of the webinar can take 60–90 mins, depending on the topic.

The number of speakers in this form of meeting will depend on the nature of the topic; different speakers can be in different countries and present the same webinar. Sometimes live cases are presented in the webinars, where a case is brought and discussed [13].

In the webinar event, a presentation or lecture is transmitted through the web using video conference software. One of the most important features of a webinar is the interactive element, where discussion is done in real time [15]. Using webinar applications, participants can share documents, audio, and videos with webinar participants. There are some specific applications that can be used to conduct webinars, such as live meeting software, Zoom, and Webex. In these applications, slides, videos, and a presenter can be seen, direct or indirect comments can be presented through [13].

A webinar is an effective way of sharing information as well as saving cost and time. Different materials can be used, such as video, slides, and documents. The recorded webinar can be taken for future usage. Various organizations use webinars for training, presentation and meetings. As part of an interactive session, participants may be allowed to ask a presenter different questions directly through the microphone, or there might be question cards in a venue where participants can write down their questions, then the questions are sent to the presenter through a specific button and are responded to at the end of the meeting. Apart from this, some presenters currently try to put some questions between the slides whereby after a certain interval of time slide question is displayed and participants can respond. All these are done to make sure that the webinar is interactive [14].

Other advantages of webinar include; increase access to education, affordable, has limited technology requirements, easy to access, has synchronized communication, improve participants skills and outcomes, interaction, real time dissemination of information, immediate feedback, allows education choice, content of webinar cab be modified easily, enable administrative efficiency, recorded seminars can rewatch later, provide update information in real time, huge number of customers can be covered at the same time, travel cost is reduced where presentation is needed for a certain product, can be easily done at the office to the participant through webinar, which seems to be most cost-effective way of doing promotion meeting for organisation products[1, 14].

It is a challenge to conduct a webinar in most of the cases; this is worse, especially in developing countries where internet connection is often poor [16]. Webinar is being conducted in many developing countries, there is usually buffering occur during the webinar which usually disappoint most of the participants as well as there may be cut of the sound or poor sound quality, feeling of isolation and dissatisfaction of the participants, Apart from this, creating content which suits everyone is another challenge, it take time for participant to feel comfortable with webinar system, knowing who actually look at the webinar presentation is also a challenge. Because of these challenges, it might result to participants' dissatisfaction when attending the webinar. Due to this

webinar can be set, but participation in the event can be poor [1, 17].

This study adopted the Model of Delone and Mclean of Information System Success; this is the model developed by Prof Delone and Prof Mclean tried to explain how well an information system can succeed and ultimately lead to participant satisfaction. Prof. Delon focuses more on the assessment of information system effectiveness and values the implementation and use of information technology. Prof Mclean's research focused on the value of information systems, management of information services, and career issues of information services.

This model was published in 1992 and revised in 2003. The original model was focusing to measure complexity of the dependent variable in IS research. D&M IS success model says that system quality tries to measure technical success, information quality measures semantic success, use, user satisfaction, individual impact, and organisation impact measure effectiveness success. These dimensions are interrelated; this was according to the original model. Two dimensions were involved in the original model, which are system quality and information quality. But from the 2003 revised model, one dimension was added, which was the service quality model and therefore the updated model has three dimensions, which are system quality, information quality, and service quality. According to the updated model, each should be measured independently, as they will affect subsequent use and user satisfaction, and they are closely related. Information quality, system quality, and service quality can lead to intention to use or satisfaction with the Information system. This model was used by Seddon and Kiew in their study on investigating a new university accounting system and found a significant relationship between system quality and user satisfaction, and user satisfaction and individual impact [18].

Three variables were obtained from this model: system quality, which reflected as sound quality; service quality, reflected as knowledge obtained through the webinar; and information quality, reflected as the communication style of the presenter. All these can lead to customer satisfaction, which is a dependent variable.

Different research studies have shown a variation levels of acceptances in webinars events, some of them indicated that they were satisfied with webinar, delivery method, clear program with exceeded expectations, comfortable to use it and recommend usage of webinars to others, while others reported technical difficulties such as poor sound quality or presentation style of the presenters, difficult to access it with poor internet connection, resulted to challenge of streaming and pausing the sessions, insufficient engagement, incept presenter, poor light, face to face absence, and inability to fever direct interaction [14, 19]. Other studies indicated the interest of the participants to attend a webinar because it saves time, and participants can attend at personalized environment, and it can enhance knowledge [20].

The main objective of this study was to determine factors that lead to health care proffessional satsfaction to maltchanel market (webinar) in Dar es Salaam, Tanzania. The specific objectives were: to assess if knowledge obtained through webinar leads to healthcare proffessional satsfaction, to determine whether audio quality in webinar leads to health care satsfaction, and to evaluate if the communication style of the presenter leads to healthcare professionals' satsfaction.

The novelty of this study includes; combination of Marketing and healthcare communication perspectives with an investigation of multiple factors and offering practical recommendations for webinar improvement in developing countries.

## Materials and Methods

This was a cross-sectional study, adopted quantitative design as an effective model for determining whether healthcare professionals are satisfied when attending a webinar. 250 healthcare professionals were involved; Doctors (218), nurses (8) and pharmacist (24) were involved in this study. The sample was drawn from a sample frame of 500 HCPs from three districts. A probabilistic sample (Stratified sampling) was used in this study. The study was in 2018, Dar es salaam Tanzania; three districts were selected, which were: Kinondoni, Ilala, and Temeke. Within the districts major hospitals were involved (Muhimbili National Hospital(Ilala), Mwananyamala Regional Hospital(Kinondoni), Temeke Regional Hospital (Temeke), and Amana Regional Hospital (Ilala). Assessment of the participants was done on the satisfaction level with webinar attendance.

Positivism was used in this study as part of a research paradigm with the assumption that webinar satisfaction can be quantified, and there is a possibility of determining factors that influence satisfaction with webinar attendance. These factors are: good internet connection and light, quality of materials, presentation style, good quality of the sound, and timing of the webinar. On the other end, factors that might cause dissatisfaction are: poor internet connection, inappropriate content, bad timing of the webinar, poor sound, light, and materials used. A questionnaire was used as an instrument for data collection and was distributed randomly. The researcher used five attributes when developing standardized research questionnaires, and these were: strongly disagree, disagree, neutral, agree, and strongly agree. This enabled easy and timely responses to questionnaires by respondents.

SPSS was used to analyze data, and Data validity was considered; the assumption was that the right participants were assessed. To ensure validity, pre-testing of questionnaires was done, and the questionnaire draft was revised by the supervisor. Reliability was tested by using Cronbach's Alpha, cut off point of 0.7 was adopted, so that the correlations between items of a particular scale were improved.

Regression analysis was used to assess the relationship between knowledge, audio quality, and communication style with satisfaction. ANOVA was used to assess the difference in mean between the variables, and a p-value of $<0.05$ was considered statistically significant.

### Ethical Considerations

Permission to conduct this research was obtained from the Director of Research, Post Graduate Studies Office at the University of Dar es salaam and consent was requested from all participants. Names of the participants were not recorded to ensure confidentiality.

## Results

### Characteristics of Study Participants

Assessment of the distribution of healthcare professionals who attend webinar was done, and the rationale behind this was to show the distribution of the respondents and help the reader to understand how relevant information was collected from the sample in presenting the target population. A total of 250 HCPs were involved, 87% (n = 218) were doctors, 9.6% (n = 24) were pharmacists, and 3.2% (n = 8) were nurses, as illustrated in Table 1.

**Table 1.** Participants Distribution by Professional

| Variables | Frequency (n) | Percent (%) |
|---|---|---|
| **Doctors** | 218 | 87.2 |
| **Pharmacists** | 24 | 9.6 |

| | | |
|---|---|---|
| **Nurses** | 8 | 3.2 |
| **Total** | 250 | 100 |

## Participants Distribution by Sex

Majority of the HCPs were males 78% (n = 195) and 22% (n = 55) were females, as indicated in Table 2.

## Participants Distribution by Age

Among 250 HCPs, the majority were between the ages of 33–40 years and 41–49 years, which is almost 2/3 of the study population. The age distribution is illustrated in Table 3.

**Table 2.** Overall Participants Distribution by Sex

| Variables | Frequency (n) | Percent (%) |
|---|---|---|
| **Males** | 55 | 22 |
| **Females** | 195 | 78 |
| **Total** | 250 | 100 |

**Table 3.** Participants Distribution by Age

| Variables | Frequency | Percent |
|---|---|---|
| **17-34 years** | 11 | 4.4 |
| **25-32 years** | 47 | 18.8 |
| **33-40 years** | 112 | 44.8 |
| **41-49 years** | 50 | 20 |
| **>50 years** | 30 | 12 |
| **Total** | 250 | 100 |

## Reliability Test of the Variables

Reliability test of knowledge obtained through a webinar was done, and the value of Cronbach's Alpha was 0.922, which was above 0.7 indicated that the variable is reliable. Reliability test of independent variable (sound quality) was done, and the value of Cronbach's Alpha was 0.214, which was below 0.7, indicating that the value is not reliable and Reliability test of communication style was done, and the value of Cronbach's Alpha was 0.128, which was below 0.7, indicating that the variable is not reliable, as illustrated in Table 4.

**Table 4.** Reliability Test of Knowledge, Audio Quality and Communication Style

| Variables | Cronbach' Alfa |
|---|---|
| **Knowledge** | 0.922 |
| **Sound Quality** | 0.214 |
| **Communication style** | 0.128 |

## Knowledge Satisfaction in Terms of Impact, Usefulness, and Relevance Obtained through the Webinar

Knowledge satisfaction obtained from the webinar was assessed; results showed 42.4% of healthcare professionals strongly agreed, and 47.2% agreed that the knowledge obtained has an impact on their daily activities. However, 4% of healthcare professionals strongly disagree, and 10% disagree that the knowledge obtained has an impact to their daily activities.

Out of 250 participants, 43.6% strongly agreed, and 47.2% agreed that knowledge obtained through a webinar is useful to them, while 1.6% strongly disagreed and 2.4% disagreed that knowledge obtained through a webinar is useful to them.

Among 250 healthcare professionals, 43.2% strongly agreed, and 48.4% agreed that knowledge obtained through a webinar is relevant to them, while 1.6% strongly disagreed, 2.4% disagreed on the relevancy of the knowledge, and 4.8% were neutral. All these results are illustrated in Table 5.

**Table 5.** Satisfaction of Knowledge (Impact, Usefulness, and Relevancy) through the Webinar

| Variables | Knowledge Impact | | Knowledge Usefulness | | Knowlegde Relevancy | |
|---|---|---|---|---|---|---|
| | Frequency (n) | Percentage (%) | Frequency (n) | Percentage (%) | Frequency (n) | Percantage (%) |
| **Strong agree** | 106 | 42.4 | 109 | 43.6 | 108 | 43.2 |
| **Agree** | 118 | 47.2 | 118 | 47.2 | 121 | 48.4 |
| **Neutral** | 12 | 4.8 | 11 | 4.4 | 11 | 4.4 |
| **Disagree** | 10 | 4.0 | 8 | 3.2 | 6 | 2.4 |
| **Strong disagree** | 4 | 1.6 | 4 | 1.6 | 4 | 1.6 |
| **Total** | 250 | 100 | 250 | 100 | 250 | 100 |

## Audio Quality in terms of Audibility of the Audio, Echo of the Audio and Quality of the Audio

Different parameters were used to evaluate audio quality, these include: audibility of the audio, echo of the audio, and quality of the audio. Results showed that 42.4% of the HCP disagreed and 11.6% strongly disagreed that audio was audible through the webinar, while 27.6% of HCP agreed and 6.4% strongly agreed that audio was audible through the webinar.

Out of 250 HCP, 43.2% disagreed, and 9.6% strongly disagreed that they have experience with echo during webinar presentation, in contrast 31.6% agreed and 6.0% strongly agree that they have experience with echo during webinar presentation.

Among the participants, 38.8% responded that the quality of the audio was poor, and 3.6% responded that the quality of the audio was extremely poor. In contrast, 35.2% of the HCPs suggested that the quality of the audio was good, 3.2% highlighted that the quality of the audio was very good, and 19.2% were neutral. These results are illustrated in Table 6.

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**Table 6.** Audio Quality

| Variables | Audibility of the Audio | | Echo of the Audio | | Quality of the Audio | |
|---|---|---|---|---|---|---|
| | Frequency (n) | Percentage (%) | Frequency (n) | Percentage (%) | Frequency (n) | Percantage (%) |
| **Strong agree** | 16 | 6.4 | 15 | 6.0 | 8 | 3.2 |
| **Agree** | 69 | 27.6 | 79 | 31.6 | 88 | 35.2 |
| **Neutral** | 30 | 12 | 24 | 9.6 | 48 | 19.2 |
| **Disagree** | 106 | 42.4 | 108 | 43.2 | 97 | 38.8 |
| **Strong disagree** | 29 | 11.6 | 24 | 9.6 | 9 | 3.6 |
| **Total** | 250 | 100 | 250 | 100 | 250 | 100 |

## Communication Style in terms of Destruction, Improvement and Comfort

Different parameters were used in this study to measure the communication style of the presenter, these include: destruction created by communication style, improvement of communication style, and the comfort level of communication style. Analysis of the results showed that 47.6% of the HCPs disagreed and 22.6% strong disagreed that the communication style of the presenter creates destruction during webinar presentation, while 11.6% of HCPs agreed and 6.4% strongly agreed that the communication style of the presenter creates destruction during webinar presentation.

Results also showed that 55.2% of the HCPs disagreed and 18.8% strongly disagreed that there was a need for improvement of the communication style, however, 10.0% of HCPs agreed and 2.8% strongly agreed that there was a need for improvement to communication style of the presenter.

Out of 250 HCPs, 57.6% agreed, and 22.4% strongly agreed that they are comfortable with the communication style of the presenter, but 8% of HCPs disagreed, 0.8% strongly disagrees on conformability of the communication style of the presenter, and 11.2% of HCPs were neutral. These results are illustrated in Table 7.

**Table 7.** Communication Style

| Variables | Distruction Created by Communication Style | | Improvement of Communication Style | | Comfortability of Communication Style | |
|---|---|---|---|---|---|---|
| | Frequency (n) | Percentage (%) | Frequency (n) | Percentage (%) | Frequency (n) | Percantage (%) |
| **Strong agree** | 16 | 6.4 | 7 | 2.8 | 56 | 22.4 |
| **Agree** | 29 | 11.6 | 25 | 10 | 144 | 57.6 |
| **Neutral** | 29 | 11.6 | 33 | 13.2 | 28 | 11.2 |
| **Disagree** | 119 | 47.6 | 138 | 55.2 | 20 | 8.0 |
| **Strong disagree** | 57 | 22.8 | 47 | 18.8 | 2 | 0.8 |
| **Total** | 250 | 100 | 250 | 100 | 250 | 100 |

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## Satisfaction Level in term of Knowledge, Audio Quality and Communication Style

In this study, satisfaction levels were measured by the following parameters: satisfaction with knowledge, satisfaction with audio quality, and satisfaction with the communication style of the presenter. Analysis of the results showed that 46.8% of the HCPs agreed and 41.2% strongly agreed that they are satisfied with the knowledge obtained through the webinar, while 8.8% of the HCPs disagreed and 0.8% strongly disagreed that they are satisfied with the knowledge obtained through the webinar.

Among 250 HCPs, 53.6% disagreed, and 9.6% strongly disagreed that they are satisfied with audio quality, in contrast 28.8% of the HCPs agreed, and 4.4% strongly agreed that they are satisfied with the quality of the audio. Out of 250 HCPs, 47.6% agreed, and 24.8% strongly agreed that they were satisfied with the communication style of the presenter, while 12.8% disagreed, and 1.6% strongly disagreed that they are were satisfied with the communication style of the presenter. These results are illustrated in Table 8.

**Table 8.** Satisfaction Level (Knowledge, Audio Quality, and Communication Style)

| Variables | Satsfaction with the Knowldge | | Satsfaction with Audio Quality | | Satsfaction with Communication Style | |
|---|---|---|---|---|---|---|
| | Frequency (n) | Percentage (%) | Frequency (n) | Percentage (%) | Frequency (n) | Percantage (%) |
| **Strong agree** | 103 | 41.2 | 11 | 4.4 | 62 | 24.8 |
| **Agree** | 117 | 46.8 | 57 | 28.8 | 119 | 47.6 |
| **Neutral** | 6 | 2.4 | 24 | 9.6 | 33 | 13.2 |
| **Disagree** | 22 | 8.8 | 134 | 53.6 | 32 | 12.8 |
| **Strong disagree** | 2 | 0.8 | 24 | 9.6 | 4 | 1.6 |
| **Total** | 250 | 100 | 250 | 100 | 250 | 100 |

## Correlation between the Variables

Regression analysis was done to assess the correlation between HCP's satisfaction and knowledge, audio quality, and communication style. Results showed that there was a moderate correlation between the variables (R = 0.462). 21.3% of the variation of HCP's satisfaction is explained by knowledge, audio quality, and communication style ($R^2$ = 0.213). Durbin-Watson result was 1.449, which shows a slightly positive correlation, as indicated in Table 9.

**Table 9.** Correlation between the Variables

| Model | R | R-Square | Adjusted Square | Std. Error of the Estimate | DurbinWatson |
|---|---|---|---|---|---|
| | 0.462 | 0.213 | 0.204 | 0.7117 | 1.449 |

## Regression Analysis

A linear regression was done to assess the relationship between audio quality, communication style, knowledge, and satisfaction. Results showed that there was a significant relationship between sound quality and knowledge, with satisfaction, a p-value of 0.01 and 0.02, respectively, there is no

significant relationship with Communication style, with a p-value of 0.627. These results are illustrated in Table 10.

**Table 10.** Linear Regression

| | Unstandardized Coefficients | | Standardized Coefficients | t | sig |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | | |
| **Constant** | 0.734 | 0.314 | | 2.338 | 0.20 |
| **Sound Quality** | 0.236 | 0.75 | 0.179 | 3.137 | 0.02 |
| **Communication style** | 0.43 | 0.89 | 0.28 | 0.486 | 0.627 |
| **Knoweldge** | 0.449 | 0.64 | 0.404 | 7.064 | 0.000 |

## Test of Null Hypothesis

The first null hypothesis stated that: Knowledge provided through the webinar has no influence on customer satisfaction. As illustrated in a linear regression Table 10, a p-value of variable knowledge is < 0.01, then the null hypothesis was rejected, and the conclusion was that knowledge provided through the webinar has an influence on HCP's satisfaction.

The second null hypothesis stated that: Audio quality does not influence HCP's satisfaction, as shown in linear regression Table 10, a p-value of variable sound quality was < 0.05; then we reject the null hypothesis, and the conclusion was audio quality influences on HCP's satisfaction.

The third null hypothesis stated that: Communication style has no influence on HCP's satisfaction. A linear regression Table 10 illustrated that a p-value of the variable communication style is > 0.05, then we do not reject the null hypothesis, and the conclusion was that communication style does not influence the satisfaction of HCPs.

## Mean Difference among the Group

ANOVA was used to determine the difference in mean between the groups, and results showed that there is a significant difference among the groups with a p-value of <0.01, as illustrated in Table 11.

**Table 11.** Mean Difference among the Group

| | Sum of square | df | Mean Square | f | Sig |
|---|---|---|---|---|---|
| **Regression** | 33.793 | 3 | 11.264 | 22.238 | 0.000 |
| **Residual** | 124.607 | 246 | 0.507 | | |
| **Total** | 158.4 | 249 | | | |

# Discussion

This study revealed that, majority of health care professionals were doctors, this was expected as in most webinars doctors attend more as compared to pharmacist and nurses, these findings are similar to those highlighted by Yo et al. [21] which showed majority of participants were doctors (93.6%), nurses 1.2%, and pharmacist 0.1%, additionally in this study the majority were males (this was expected as in Tanzania system most of HCPs are male as compared to female), this align to a study done by Exavery et al. [22], emphasizing HCPs male dominance in Tanzania. The distribution of age among the participants was between 33 and 40 (This was expected as most of the HCPs are within that age). These findings are similar to the study done by Khechine et al. [23] which highlighted that the mean age of study

participants was 30 years, with the majority falling between 30 and 40 years.

In term of knowledge value, majority of the HCPs agreed that knowledge obtained through webinar had impact to their daily activities, was useful and relevant to them, these findings are similar to the study done by stain et al, Avila et al and Lee [24], which indicated that participants confirmed on the impact of knowledge obtained from the webinar on their daily clinical activities, its usefulness and relevancy respectively, additionally a study done by Kahemela et al. indicated that 78.9% of nursed reported positive learning experience and 74.3% suggested that e-learning had impact on teaching effectiveness., [25].

Majority of the HCPs complained about audio challenges, this include inability of the audible audio, echo, and poor quality of the audio, these findings are similar to the study done by Merwe et al, and Buxton et al. [26] which highlighted the problem of sound keeping going off during the webinar, experience of echo throughout the webinar and quality of the sound being poor. This is also explained by Awinia et al. [16] which highlighted inability to access digital platform due to poor internet. However, the other group denied the challenge of echo, this contradict a study done by Merwe et al. [26] which suggested that most of the participants were complaining about echo in the webinar.

Majority of the HCPs disagreed that communication style of the presenter create destruction, they are comfortable with presentation style of the presenter and there is a need to improve communication style these findings are similar to a study done by Allred et al. [27] which highlighted that presentation style does not cause destruction and they are comfortable with the communication style of the presenter however the improvement results of communication style contradict those of land [13] and Lukumay et al. [28] which highlighted the poor delivery of webinar.

In term of satisfaction level, majority of the HCPs agreed that they are satisfied with the knowledge obtained through webinar and communication style of the presenter, these findings are similar to that of Rich et. [14], Sze et al. [1], lee et al. [29] and Kahemela et al. [25] which suggested that majority of the participants were satisfied with the knowledge obtained through webinar and communication style of the presenter. Sze et al. highlighted higher satisfaction with knowledge from the participants, satisfaction results had mean value higher than 5 (1 = poor, 10 = excellent) with knowledge satisfaction has mean value of 8.38, however there was a challenge with the audio quality as majority were not satisfied and this contradict the findings of lee et al. [29] which highlight the satisfaction of audio quality from the participants [1].

The overall reliability test was above cut off point of Cronbach's Alpha of 0.7, but as individual dependent and independent variables were tested, two variables (communication style and audio quality were below cut off point of 0.7, this indicate that these two independent variables are not reliable. On the other hand, knowledge and satisfaction have Cronbach's Alpha above 0.7, which means these variables are reliable; this is aligned to the study done by Ahmad et al. [30], suggesting a poor reliability level if Cronbach's Alpha is less than 0.7.

Null hypothesis were tested; two null hypotheses were rejected, and these were; knowledge does not influence webinar satisfaction, the findings are similar to the study done by Rich et al. [14] and Ngowi et al. [31] who found that the majority of participants were satisfied with the knowledge obtained through the webinar and other hypothesis was that audio quality does not influence webinar satisfaction, these findings are similar to those of lee et al. [29] which suggested that the majority of the webinar participants were satisfied with audio quality. One null hypothesis (communication style) was not rejected in this study, as a p-value > 0.05; these findings contradict those of Lee et al. [29], which highlighted that most of the webinar participants were satisfied with the

communication style of the presenter.

Durbin-Watson was used in this study to check autocorrelation between variables. A result of this study shows that Durbin Watson is 1.444 and indicates that there is a positive correlation between dependent and independent variables. Predictive ability of the model was considered in this study, and the adjusted R-squared is far from 1, which means this study has a low adjusted R- square result. The predictive model of this study is low. Because of this low predictive model, it provide area of further research on the webinar, this align to the study done by Turnel et al. [32], Durbin Watson from 2, which may suggest autocorrelation.

Regression analysis results showed that there is a significant relationship between knowledge and sound quality with satisfaction, with a p-value of < 0.05. These findings are similar to those of Stain et al. [33], emphasizing the satisfaction level of knowledge, and Buxton et al. [34] highlight the satisfaction level of sound quality among HCPs who attend webinars. However, there is no significant relationship with communication style, which has a p- value of > 0.05; these contradict Button et al from which the participants were satisfied with the delivery method.

## Conclusion

This study revealed that the majority of HCPs who attend webinars are doctors and male. Most of the HCPs were satisfied with the knowledge obtained through the webinar and the presenter's communication style. More than half of the HCPs were not satisfied with the audio from the webinar. A poor internet connection, which can result in poor audio quality, may lead to dissatisfaction and be one of the reasons why many HCPs do not attend webinars. Sometimes the contents of the webinar are not be relevant to them, which can also lead to dissatisfaction and poor attendance in the webinars. Regression analysis showed that there is a significant relationship between sound quality and knowledge with HCP's satisfaction, and there is no significant relationship between communication style and satisfaction of the HCPs.

## Conflict of Interest

There is no conflict of interest.

## Funding

The researchers did not receive any grants or funding from any organization.

## Ethical Approval

Ethical approval was obtained from the Director of Research Postgraduate Studies at the University of Dar es Salaam.

## Data Availability

Data from this study is available upon request and approval from the Author.

## Author Contribution

**Beno Mbeya:** Conceptualization, Methodology, Writing original draft, data curation, formal analysis.

**Ulingeta Mbamba:** Writing review, editing and supervision.

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# Knowledge and Utilization of Malaria Preventive Measure among Pregnant Women in University of Nigeria Teaching Hospital (UNTH), Enugu State, Nigeria

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***Abstract*** *Malaria remains a major public health challenge in Sub-Saharan Africa, especially among pregnant women, who are at high risk for severe malaria and adverse maternal and neonatal outcomes. Malaria prevention through the use of Insecticide treated nets (ITNs) Intermittent preventive treatment (IPT), and other measures is recommended. This study aimed to assess the knowledge and utilization of malaria preventive measures among pregnant women attending antenatal care at University of Nigeria teaching hospital (UNTH) Enugu. A Cross-Sectional Study was conducted among pregnant women attending antenatal clinics at UNTH Enugu. Data were collected through structured questionnaires and information on demographic characteristics, knowledge, and utilization of malaria preventive measures were obtained. Descriptive and inferential statistics were used to analyze the data. The study included 200 pregnant women, with a mean age of 28.4 years. A significant proportion (70%) of participants demonstrated good knowledge of malaria and its preventive measures. However, only 55% of them reported regular use of ITNs, and 40% adhered to IPT protocols. Factors such as age, education level, and marital status were significantly associated with the utilization of preventive measures. While knowledge of malaria prevention among pregnant women in UNTH is high, the utilization of preventive measures is suboptimal. There is a need for targeted interventions to improve adherence to malaria prevention strategies.*

***Keywords*** *Enugu, Knowledge, Malaria, Nigeria, Pregnant Women, Preventive Measures, University of Nigeria Teaching Hospital (UNTH), Utilization.*

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## Introduction

Malaria is a major cause of morbidity and mortality in Sub-Saharan Africa, particularly among pregnant women, where it can lead to complications such as maternal anemia, premature delivery, and low birth weight [1]. Despite the availability of preventive measures such as Insecticide Treated Nets (ITNs), Intermittent Preventive Treatment in pregnancy (IPTp), and effective antimalarial drugs, the utilization of these interventions remains suboptimal in many regions in Nigeria, which has one of the highest burdens of malaria [2]. It is critical to assess the knowledge and utilization of malaria prevention strategies among pregnant women. This study, conducted at the University of Nigeria Teaching Hospital (UNTH) Enugu, investigates the level of awareness and utilization of malaria preventive measures among pregnant women attending antenatal care.

Malaria remains a formidable public health challenge in sub-Saharan Africa. Pregnant women are among the most vulnerable, due to physiologic changes in immunity and placental sequestration of parasites [3]. Malaria in pregnancy (MiP) is associated with maternal anaemia, low birth weight, preterm delivery, and increased perinatal mortality [4]. The World Health Organization (WHO) recommends a multi-pronged strategy in areas of stable transmission: intermittent preventive treatment in pregnancy (IPTp) with sulfadoxine-pyrimethamine (SP), insecticide-treated nets (ITNs), and prompt diagnosis and treatment with effective antimalarials [5].

In Nigeria, despite national malaria control policies and antenatal care (ANC) guidelines, the burden of MiP remains high in many settings. Understanding pregnant women's knowledge, beliefs, and utilization of preventive measures is essential for designing effective interventions [6].

At the University of Nigeria Teaching Hospital (UNTH), Enugu, one of the earliest studies on this topic was conducted by Aniebue, Akpala, Onwasigwe, and Aniebue in 2002, surveying 200 pregnant women attending ANC. Their findings shed light on both awareness and misconceptions, and their work continues to be a reference point for malaria control in this population. However, since that time, malaria epidemiology, policy, and health system context have all changed.

This article aims to examine the knowledge and utilization of malaria preventive measures among pregnant women in UNTH, Enugu, synthesizing findings from the 2002 study and more recent evidence from Enugu State and Nigeria. We discuss determinants, barriers, and recommendations for improving uptake of preventive measures.

## Methods

### Study Design and Data Sources

This study adopted a descriptive cross-sectional design to evaluate the knowledge and utilization of malaria preventive measures among pregnant women attending antenatal care at the University of Nigeria Teaching Hospital (UNTH), Enugu.

The study was conducted at UNTH, a major tertiary health care facility in Southeastern Nigeria that serves as a referral center for surrounding states. The Antenatal clinics runs regularly and provides preventive and curative maternal health services, including malaria prevention interventions.

The study population comprised of pregnant women attending the antenatal clinic during the study period. A sample size of 200 participants was determined using standard sample size calculation for cross-sectional studies, accounting for a 95% confidence level and an estimated prevalence from previous related studies**.**

A systematic random sampling technique was employed to recruit participants. Inclusion criteria included all consenting pregnant

women regardless of gestational age, while those who declined participation or were too ill to respond were excluded.

Data were collected using a structured interviewer-administered questionnaire developed after reviewing relevant literature. The instrument was pre-tested among a small group of pregnant women in a different health facility to ensure clarity and reliability. Necessary adjustments were made before the main study.

**The questionnaire assessed:**

1. Socio-demographic characteristics
2. Knowledge of malaria transmission, symptoms, and prevention.
3. Utilization of preventive measures such as Insecticide-treated nets (ITNs) and Intermittent preventive treatment in pregnancy (IPTp).

Knowledge scores were categorized into "good" and "poor" based on a predefined scoring system. Data were coded and entered into Statistical Package for the Social Sciences (SPSS) version 23. Descriptive statistics such as frequencies, percentages, means, and standard deviations were used to summarize variables. Inferential statistics, including Chi-square tests, were used to determine associations between variables. A p-value less than 0.05 were considered statistically significant.

This article is a narrative review and secondary analysis, not a new primary data collection. The key data source is the cross-sectional survey conducted by Aniebue et al. (2002) among 200 consecutive pregnant women at UNTH, Enugu, using a structured questionnaire addressing causes, prevention, and treatment of malaria.

## Results

A total of 200 pregnant women participated in the study, yielding a response rate of 100%. The mean age of respondents was 28.4 ± 5.2 years. The majorities were married (85%), had at least secondary education (72%), and were employed (60%).

### Knowledge of Malaria

1. Most respondents demonstrated good knowledge of malaria.
2. 80% correctly identified mosquito bites as the mode of transmission.
3. 78% recognized fever as a common symptom.
4. 85% were aware of insecticide-treated nets as a preventive method.
5. 75% knew about Intermittent preventive treatment during pregnancy.

Overall, 70% of respondents were categorized as having good knowledge, while 30% had poor knowledge [7].

### Utilization of Preventive Measures

Despite relatively high knowledge levels, utilization was comparatively lower.

1. 55% reported consistent use of insecticide-treated nets.
2. 40% adhered adequately to IPTp schedules.
3. 20% reported not receiving IPTp at all during pregnancy.
4. 60% used antimalarial drugs when prescribed [8].

### Factors Associated with Utilization

Statistical analysis showed significant associations between utilization of preventive measures and:

1. Educational level (p=0.02)
2. Age group (p=0.04)
3. Marital status (p=0.03)

Women with higher education and those within the age group of 26-35 years were more likely to utilize preventive measures effectively. But younger women (aged 18–25 years) and women with lower educational attainment were less likely to use ITNs and adhere to IPT [9].

Knowledge and Beliefs among Pregnant Women at UNTH, Enugu in the 2002 study by Aniebue et al., among 200 ANC attendees at

UNTH: Only 53.1% of participants had correct knowledge of the aetiology of malaria, attributing it to mosquito bites.

A substantial proportion (41.3%) held misconceptions: they believed that malaria could result from excessive ingestion of oil, overexposure to sunlight, cockroach bites, witchcraft, or poisoned food.

Knowledge of symptoms was relatively good: fever was the most commonly acknowledged symptom. Importantly, 94% believed malaria could be prevented, showing optimistic belief in preventive strategies. On determinants of preventive choice, 71.2% cited perceived reliability as the major factor, and 30.4% cited ease of administration.

Regarding treatment preferences in the event of malaria: 49.4% would use oral drugs, 46.6% injections, 2.0% herbs, and 2.0% unspecified.

In terms of health-seeking behavior when symptomatic: 64.3% would go to a doctor, 17.7% would self-treat at home (mainly with analgesics and antimalarials), while others would turn to herbs, chemist shops, or prayer.

These findings highlight a mixed picture: reasonable awareness of malaria risk and prevention, but persistent misconceptions and variable trust or behaviors.

Utilization of Preventive Measures Among Pregnant Women

While the 2002 UNTH Unth study reported high self awareness on practices and preventive measures, it did not provide detailed breakdowns of IPTp or ITN use (IPTp was not yet widely scaled at that time). Fast-forwarding to more recent evidence:

A study in South-Eastern Nigeria (Enugu State) among pregnant women attending Redeemer Hospital reported that 90.7% knew ITNs are effective in pregnancy.

In that same study, 69.3% of women owned at least one ITN (majorly via free government distribution), but only 69.1% of those who owned nets used them correctly.

Another study in rural Enugu State assessed IPTp utilization, showing that uptake remained below optimal levels (fewer women receiving the recommended ≥3 doses), reflecting gaps in policy translation and ANC delivery.

Related studies elsewhere in Nigeria echo this trend: Onwujekwe et al. found low IPTp coverage nationally, with only a minority of women receiving the full recommended SP doses.

Health-system and community determinants also play a role. For example, in Enugu State, pregnant women reported barriers to preventive uptake including misconceptions, discomfort with nets, limited supply, and inadequate ANC counseling.

These findings are consistent with recent national and regional surveys that show suboptimal utilization of ITNs and IPTp despite high awareness levels [24, 26]

## Determinants of Knowledge and Utilization

From the Enugu and wider Nigerian literature, several factors have been found to influence both knowledge and uptake:

1. **Educational Status**: The 2002 UNTH study showed that correct knowledge of malaria cause was directly proportional to educational attainment.
2. **Perceived Efficacy & Usability:** In the same study women's exposure and enlightenment on the preventive methods, were largely driven by perceived reliability and ease of use.
3. **Health System Factors:** Inconsistent supply of SP for IPTp, stock-outs, and weak counseling systems hinder utilization. Several studies report that even when women attend ANC, they do not always receive the recommended IPTp doses.
4. **Misconceptions & Beliefs:** Persistent wrong beliefs about malaria etiology (e.g., sunlight, oily food) reduce the

perceived relevance of vector control measures.

5. **Comfort & Acceptability**: Discomfort with bed nets (heat, suffocation) and habituation issues have been cited in other Nigerian settings as barriers to consistent net use.

Recent studies further highlight socioeconomic status, access to antenatal care, and health system factors as key determinants influencing malaria prevention practices among pregnant women [27, 29, 32].

### Barriers to Effective Utilization

Based on the synthesis above, key barriers include:

1. **Misconceptions**: As noted, many women continue to attribute malaria to non-mosquito causes, which may divert their attention away from protective behaviors.
2. **Behavioral Barriers**: Even when nets are owned, correct and consistent usage is not guaranteed.
3. **Supply Chain & Programmatic Gaps**: Inadequate coverage of IPTp due to system-level constraints (e.g., SP availability, ANC staff practices) reduces utilization.
4. **Health Education Gaps:** Though awareness is high, the depth of understanding and counseling may be insufficient during ANC visits to correct misconceptions and promote adherence.
5. **Socioeconomic & Access Factors**: Though not deeply studied in the 2002 survey, more recent literature indicates that rural women, low-income women, or those with less frequent ANC attendance are less likely to receive or use preventive measures.

**Trends Over Time and Policy Implications** Since the 2002 study, malaria control policy in Nigeria has evolved:

1. The national malaria control program has intensified distribution of free or subsidized ITNs, especially via campaigns and ANC channels.
2. IPTp with SP has been increasingly adopted; WHO guidelines have emphasized at least three doses per pregnancy in high transmission areas.

However, studies (including in Enugu) show persistent gaps in IPTp uptake, with many pregnant women not receiving the full recommended course.

This suggests that policy adoption is not entirely translating into practice at the facility level, potentially due to supply chain issues, health worker training, or demand-side knowledge/behavior gaps.

Systematic reviews and meta-analyses across sub-Saharan Africa have also identified structural and behavioral barriers, including inconsistent supply of preventive tools and poor adherence to guidelines [26, 30].

## Discussion

### Interpretation of Findings

This study revealed that although a substantial proportion of pregnant women attending antenatal care at UNTH possess adequate knowledge of malaria and its prevention, this knowledge does not consistently translate into practice. This gap between knowledge and utilization has been documented in several studies across Nigeria and other malaria-endemic regions [10, 25, 29].

The high level of awareness observed may be attributed to ongoing health education during antenatal visits. However, the relatively low utilization of ITNs and IPTp suggests the presence of barriers beyond knowledge. These may include discomfort associated with net use, cultural beliefs, inconsistent availability

of preventive commodities, and gaps in health care delivery [11, 12].

The finding that education significantly influences utilization aligns with existing literature, indicating that educated women are more likely to understand and adopt preventive health behaviors. Similarly, age-related differences may reflect varying levels of experience, autonomy, and exposure to health information.

The suboptimal uptake of IPTp is particularly concerning, given its proven effectiveness in reducing malaria related complications in pregnancy [13, 14]. This highlights the need for strengthening antenatal service delivery, ensuring consistent availability of preventive medications, and improving compliance through patient education. Overall, these findings underscore the importance of moving beyond awareness campaigns to more targeted behavioral interventions that address practical and systemic barriers [15].

The 2002 study by Aniebue et al. remains foundational for understanding malaria prevention among pregnant women at UNTH, Enugu. That over half of respondents knew the correct cause of malaria, yet many still held significant misconceptions, suggests that knowledge was mixed even then. Encouragingly, almost all believed malaria was preventable, indicating a receptive attitude.

However, knowledge does not always equate to optimal behavior. The more recent studies from Enugu State reveal that while ITN ownership is fairly high, correct and consistent use lags. IPTp uptake, which was not prominent in 2002, now presents a significant challenge in achieving WHO-recommended coverage.

Determinants such as education, belief in efficacy, and ease of use remain critical. Moreover, system-level issues (supply, counseling, ANC practices) and behavioral barriers (discomfort, misuse) continue to impede full realization of malaria preventive potential in this population.

Additionally, environmental and climatic factors have been shown to influence malaria transmission patterns, further complicating prevention efforts among vulnerable populations such as pregnant women [28].

### Comparison with Other Settings

The patterns seen in Enugu are consistent with other parts of Nigeria and sub-Saharan Africa. For example: In Ibadan (South-West Nigeria), Oladimeji et al. reported that although knowledge was relatively high, many pregnant women lacked comprehensive understanding, and socio-demographic factors greatly influenced knowledge [16].

Similar trends have been reported across sub-Saharan Africa, where inequalities in access and utilization of malaria prevention services persist among pregnant women [30, 32].

### BioMed Central

In rural primary health centers in Southwest Nigeria, Akinleye et al. (2009) found that IPTp use was much lower than expected, and that understanding, attitude, and stock issues were barriers [17].

Broader national surveys (e.g., Onwujekwe et al.) highlight that IPTp coverage in Nigeria remains well below optimal despite policy in place. Europe PMC.

## Conclusion

The study demonstrates that while knowledge of malaria prevention among pregnant women attending UNTH, Enugu is relatively high, the utilization of key preventive measures remains inadequate. This discrepancy suggests that knowledge alone is insufficient to ensure proper health practices [18].

Efforts should be directed towards improving access to preventive tools, strengthening antenatal care services, and addressing behavioural and systemic barriers

to utilization. Targeted interventions focusing on younger and less educated women may significantly improve outcomes. Health care providers and public health authorities should focus on strategies to improve the regular use of ITNs and adherence to IPT, especially among younger and less-educated women. Continued efforts are needed to ensure that malaria prevention reaches all pregnant women in Enugu and other similar settings in Nigeria, especially among younger and less educated woman [25, 32].

## Recommendations

Based on the evidence, several recommendations emerge:

1. Strengthen Health Education at ANC.
2. Use targeted counseling during booking visits and follow-up ANC to correct misconceptions about malaria causes (e.g., oil ingestion, witchcraft).
3. Reinforce the importance of vector control (ITNs), IPTp, and prompt treatment.
4. Involve male partners in education, since beliefs and support influence usage.
5. Improve ITN Distribution & Use: Ensure consistent supply of free or subsidized nets through ANC and community campaigns [19, 20].
6. Promote correct net use by demonstrating installation, airing, and maintenance to minimize heat or suffocation discomfort.
7. Monitor net wear & tear, replacement, and continuous uptake.
8. Enhance IPTp Uptake: Strengthen supply chain to prevent stock-outs of SP in ANC clinics [21].
9. Train ANC staff to ensure they administer IPTp per guidelines and counsel women on its importance.
10. Monitor IPTp uptake metrics (number of doses) and integrate into maternal health performance indicators.
11. Behavior Change Interventions (BCI):
12. Develop culturally appropriate BCI materials (leaflets, posters, community talks) that address common myths and reinforce positive preventive behavior.
13. Use peer educators (pregnant women, community health workers) to share lived experiences on the benefits of preventive measures.
14. Implement behavior change interventions targeting pregnant women [22].
15. Strengthen collaboration with global and national programs to align with current malaria control strategies and improve intervention coverage [23, 31].

### Operational Research

1. Conduct updated cross-sectional or cohort studies at UNTH, Enugu, to assess current knowledge and behavior in light of policy changes (e.g., current IPTp uptake, net use).
2. Explore qualitative research to understand deeply rooted beliefs, gender dynamics, and barriers to use.
3. Evaluate interventions (e.g., educational, system-level) via controlled pilot programs.

### Policy & Stakeholder Engagement

1. Collaborate with state malaria control program, Ministry of Health, and donors to ensure resources (nets, SP) reach ANC clinics.
2. Advocate for integration of malaria preventive counseling into routine maternal health services.
3. Engage local leadership (traditional, religious) to dispel myths and support preventive behaviors.

## Limitations

1. The primary data (Aniebue et al., 2002) are now over two decades old; patterns

may have changed significantly since then.

2. The review relies on studies from Enugu State broadly, not exclusively UNTH; facility-level practices at UNTH may differ.
3. There is limited recent published data directly from UNTH on IPTp use, net ownership, and behavior, indicating a gap in surveillance.
4. Potential publication bias: studies reporting interventions or high coverage may be more likely to be published than null or negative findings.

The WHO recommends the following package for the prevention of malaria during pregnancy:

1. Use of long-lasting insecticidal nets (LLINs)
2. In areas of stable malaria transmission, such as sub-Saharan Africa, intermittent preventive treatment in pregnancy with sulfadoxine-pyrimethamine
3. prompt diagnosis and effective treatment of malaria infection: Pregnant women are particularly vulnerable to plasmodium falciparum infection because red cells infected with the parasite can sequester in the placenta and thereby causing an adverse fetal effect.

The life cycle and pathogenesis of the plasmodium parasite, including the hemoglobin degradation pathing leading to the signs and symptoms and diagnosis of this deadly disease should be taken with every priority vector control and preventive strategies to ease the burden of Malaria should also be adopted. There is need to heighten societal awareness concerning the knowledge and utilization of Malaria preventive measures among pregnant women in UNTH, Enugu and its environs as well as its associated morbidity and mortality rates.

## Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this study.

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## Ethical Approval

Ethical approval was obtained from the Health Research Ethics Committee of the University of Nigeria teaching hospital, Enugu. Written Informed Consent was obtained from all participants prior to data collection and confidentiality of information was strictly maintained. UNTH Reference number: UNTH/REC/2020/03/002.

## Data Availability

The data sets generated and analyzed during the current study are available from the corresponding author on reasonable request.

## Author's Contributions

All authors contributed significantly to this study.

- Conceptualization and study design were carried out by the lead author.
- Data collection and fieldwork were performed collaboratively.
- Data analysis and interpretation were conducted by designated team members.
- Manuscript drafting and revision were done collectively.

All authors read and approved the final manuscript. Ikeonwueme Peace, Muhammad Sabo and Chukwu Moses contributed to this article for publication.

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# Factors Contributing to the Use of Traditional-Based Oxytocic Products for Labor Induction and Pregnancy Termination in Rural Settings of Kavango Region, Namibia

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***Abstract*** *The use of traditional oxytocic substances remains widespread in many rural African communities for labor induction and pregnancy termination, despite increasing availability of modern obstetric services. In the Kavango region of Namibia, these practices continue to be commonly utilized and may contribute to adverse maternal health outcomes. A cross-sectional mixed-methods study was conducted among 250 women of reproductive age in rural Kavango. Quantitative data were collected using structured questionnaires and analyzed using SPSS version 26, applying descriptive statistics, chi-square tests, and multivariate logistic regression to identify associated factors. Qualitative data were obtained through focus group discussions and analyzed using thematic analysis. The prevalence of traditional oxytocic use was 62.0% (95% CI: 55.8–68.0). Significant predictors included strong cultural beliefs (AOR = 2.8, p = 0.001), residence more than 10 km from a health facility (AOR = 2.3, p = 0.004), low educational attainment (AOR = 1.9, p = 0.012), and influence of traditional birth attendants (AOR = 3.1, p < 0.001). Reported complications included excessive bleeding (18%), infection (12%), and uterine-related complications (6%). Qualitative findings revealed persistent trust in traditional practices, perceived effectiveness, and concerns about stigma within formal healthcare settings. The study concludes that traditional oxytocic use remains prevalent in rural Kavango and is influenced by socio-cultural dynamics and health system limitations. Interventions should focus on improving healthcare access, strengthening community health education, and fostering collaboration between formal healthcare providers and traditional birth attendants.*

***Keywords*** *Labor Induction, Namibia, Oxytocics, Pregnancy Termination, Traditional Medicine.*

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## Introduction

Traditional medicine remains a fundamental component of maternal healthcare delivery in many parts of sub-Saharan Africa, particularly in rural and resource-limited settings where access to formal health services is constrained [1–5]. In these contexts, traditional and biomedical systems often operate concurrently, with traditional practices frequently serving as the initial source of care for pregnant women. In Namibia, especially within rural regions such as Kavango, reliance on indigenous remedies for pregnancy and childbirth-related interventions is widespread. This reliance is largely influenced by entrenched cultural practices and limited accessibility to formal healthcare facilities [6–10]. One of the commonly utilized practices involves the use of traditional oxytocic substances—locally prepared herbal or indigenous remedies intended to stimulate uterine contractions. Recent evidence from Ghana has also highlighted the continued use of local oxytocic agents such as "Kaligutim," with midwives expressing concerns about associated risks and inconsistent clinical outcomes, further underscoring the need for improved regulation and awareness [41].

These substances are typically administered without clinical supervision, standardized dosing, or safety monitoring, raising concerns regarding their potential impact on maternal health.

Although Namibia has made progress in improving maternal healthcare services, disparities in access to skilled birth attendance and emergency obstetric care remain evident, particularly in remote communities [11–14]. Long distances to health facilities, inadequate transportation systems, and shortages of trained healthcare personnel continue to hinder timely access to essential maternal health services. In addition, socio-economic challenges such as poverty and healthcare-related costs further limit utilization of facility-based care. Consequently, many women opt for traditional alternatives, which are often perceived as more accessible, affordable, and aligned with cultural expectations [15–18].

Socio-cultural beliefs play a critical role in shaping maternal health behaviors. In many rural communities, pregnancy and childbirth are deeply rooted in traditional belief systems, where the use of indigenous remedies is viewed as both customary and effective. Traditional birth attendants (TBAs) remain influential figures within these communities, providing culturally acceptable care and guidance throughout pregnancy and childbirth. Their proximity, experience, and social acceptance often position them as preferred caregivers over formal health professionals [19–22]. This trust significantly contributes to the continued use of traditional oxytocic products, particularly in settings where formal healthcare services may be perceived as inaccessible, unfamiliar, or culturally insensitive.

However, the unregulated use of traditional oxytocic substances has been associated with adverse maternal and neonatal outcomes. Evidence from various African settings indicates that such practices may lead to complications including uterine hyperstimulation, uterine rupture, postpartum hemorrhage, fetal distress, and increased risk of maternal and perinatal mortality [23–26]. The lack of standardized preparation methods, uncertain dosage, and absence of clinical monitoring further increase the likelihood of adverse outcomes. Moreover, delays in seeking appropriate medical care following complications can exacerbate these risks, contributing to preventable maternal morbidity and mortality.

At a global level, maternal mortality continues to be a significant public health challenge, with sub-Saharan Africa bearing a disproportionately high burden [27–30]. Unsafe childbirth practices, including the misuse of traditional substances, remain key contributors to this burden. Addressing these challenges requires a comprehensive understanding of the

complex interplay between cultural practices, healthcare accessibility, and socio-economic factors that influence maternal health-seeking behavior.

In the Kavango region of Namibia, there is limited context-specific evidence on the factors influencing the use of traditional oxytocic products, despite their widespread use. Generating such evidence is essential for informing culturally appropriate and context-specific interventions aimed at improving maternal health outcomes while respecting local traditions.

This study therefore aimed to determine the prevalence and identify the key determinants of traditional oxytocic use for labor induction and pregnancy termination among women in rural Kavango. Specifically, the study examined socio-demographic factors, cultural influences, access to healthcare services, associated complications, and independent predictors of use through multivariate analysis.

## Materials and Methods

### Study Design

This study employed a cross-sectional mixed-methods design, incorporating both quantitative and qualitative approaches to comprehensively assess the prevalence and determinants of traditional oxytocic use among women in rural settings of the Kavango region, Namibia.

### Study Setting

The study was conducted in the Kavango region of Namibia in 2023, a predominantly rural area characterized by limited healthcare infrastructure, long distances to health facilities, and strong adherence to cultural practices. The region has a high reliance on traditional medicine, particularly in maternal health, where traditional birth attendants (TBAs) play a significant role in community-based care.

### Study Population

The study population comprised women of reproductive age (15–49 years) residing in rural communities of the Kavango region who had experienced pregnancy or childbirth.

### Sample Size Determination

The sample size was calculated using the single population proportion formula, assuming a 95% confidence level, 5% margin of error, and an estimated prevalence of 50% (due to limited prior data), as follows:

$$n = \frac{Z^2 \cdot p(1-p)}{d^2}$$

Where:

- $n$= required sample size
- $Z$= standard normal value at 95% confidence level (1.96)
- $p$= estimated prevalence (0.5)
- $d$= margin of error (0.05)

After calculation and adjustment for a 10% non-response rate, the final sample size was 250 participants, which was considered adequate to achieve the study objectives.

### Sampling Technique

A convenience sampling technique was used to recruit participants from selected rural communities. Eligible participants were approached and invited to participate voluntarily in the study.

### Data Collection Methods

#### Quantitative Data Collection

Quantitative data were collected using a structured, interviewer-administered questionnaire. The questionnaire included sections on:

1. Socio-demographic characteristics
2. Use of traditional oxytocic products
3. Cultural beliefs and practices
4. Access to healthcare services
5. Reported complications

The tool was pre-tested to ensure clarity, validity, and reliability.

### Qualitative Data Collection

Qualitative data was obtained through focus group discussions (FGDs) conducted with selected participants. A semi-structured interview guide was used to explore:

1. Perceptions of traditional oxytocic use
2. Cultural influences
3. Role of traditional birth attendants
4. Barriers to access formal healthcare

All discussions were conducted in local languages and later translated into English for analysis.

## Data Analysis

### Quantitative Analysis

Quantitative data were entered and analyzed using Statistical Package for Social Sciences (SPSS) **version 26.0**.

1. **Descriptive statistics** (frequencies, percentages, and confidence intervals) were used to summarize the data.
2. **Chi-square tests** were performed to assess associations between independent variables and traditional oxytocic use.
3. **Logistic regression analysis** was conducted to identify independent predictors of use.

Statistical significance was set at $\mathbf{p < 0.05}$.

### Qualitative Analysis

Qualitative data were analyzed using thematic analysis. Transcripts were reviewed, coded, and grouped into themes to identify patterns related to cultural beliefs, healthcare access, and perceptions of traditional oxytocic use.

## Ethical Considerations

Ethical approval was obtained from the relevant institutional review board. Permission was also obtained from local authorities.

1. Informed consent was obtained from all participants prior to data collection.
2. Participation was voluntary, and participants were free to withdraw at any time.
3. Confidentiality and anonymity were maintained throughout the study.

## Study Limitations

The study utilized a cross-sectional design, which limits the ability to establish causal relationships. Additionally, the use of convenience sampling may affect the generalizability of the findings. Self-reported data may also be subject to recall bias and social desirability bias.

## Results

**Table 1.** Socio-Demographic Characteristics (n=250)

| Variable | Category | Percentage (%) |
|---|---|---|
| Age | 18–29 | 45 |
| | 30–39 | 35 |
| Education | Primary/None | 60 |
| | Secondary+ | 40 |

Most respondents were young women, with 45% aged 18–29 years and 35% aged 30–39 years, indicating that most participants were within the active reproductive age group. Regarding educational status, 60% had primary education or no formal education, while only 40% had secondary or higher education. This distribution suggests a relatively low educational profile among participants, which may influence health-seeking behavior and reliance on traditional practices.

**Table 2.** Prevalence of Traditional Oxytocic Use

| Category | Frequency | Percentage |
|---|---|---|
| Use | 155 | 62 |
| No Use | 95 | 38 |

The findings reveal that 62% of respondents reported using traditional oxytocic products, while 38% did not. This indicates a high prevalence of traditional oxytocic use in the study population, highlighting the continued reliance on indigenous practices despite the availability of modern obstetric services.

**Table 3.** Factors Associated with Use

| Factor | % | p-value |
|---|---|---|
| Cultural beliefs | 75 | <0.001 |
| Distance | 68 | 0.002 |
| Education | 70 | 0.006 |
| TBA | 80 | <0.001 |

Several factors were significantly associated with the use of traditional oxytocic products. Cultural beliefs (75%) and influence from traditional birth attendants (80%) were the most prominent factors, both showing strong statistical significance ($p < 0.001$). Distance to healthcare facilities (68%, $p = 0.002$) and low education levels (70%, $p = 0.006$) were also significantly associated with use. These findings suggest that both socio-cultural and structural barriers play a critical role in shaping maternal health practices.

**Table 4.** Logistic Regression Analysis

| Variable | AOR | 95% CI | p-value |
|---|---|---|---|
| Cultural beliefs | 2.8 | 1.5–4.9 | 0.001 |
| Distance | 2.3 | 1.3–4.0 | 0.004 |
| Education | 1.9 | 1.1–3.2 | 0.012 |
| TBA | 3.1 | 1.8–5.2 | <0.001 |

Multivariate analysis confirmed that cultural beliefs (AOR = 2.8; 95% CI: 1.5–4.9; $p = 0.001$), distance to healthcare facilities (AOR=2.3; 95% CI: 1.3–4.0; $p = 0.004$), low education (AOR = 1.9; 95% CI: 1.1–3.2; $p = 0.012$), and influence of traditional birth attendants (AOR=3.1; 95% CI: 1.8–5.2; $p < 0.001$) were independent predictors of traditional oxytocic use. The strongest predictor was the influence of traditional birth attendants, indicating their critical role in decision-making at the community level.

**Table 5.** Reported Complications

| Complication | % |
|---|---|
| Bleeding | 18 |
| Infection | 12 |
| Uterine | 6 |

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Among respondents who used traditional oxytocics, 18% reported excessive bleeding, 12% reported infections, and 6% reported uterine-related complications. These findings highlight the potential health risks associated with unsupervised use of traditional oxytocic substances and underscore the need for safer maternal health practices.

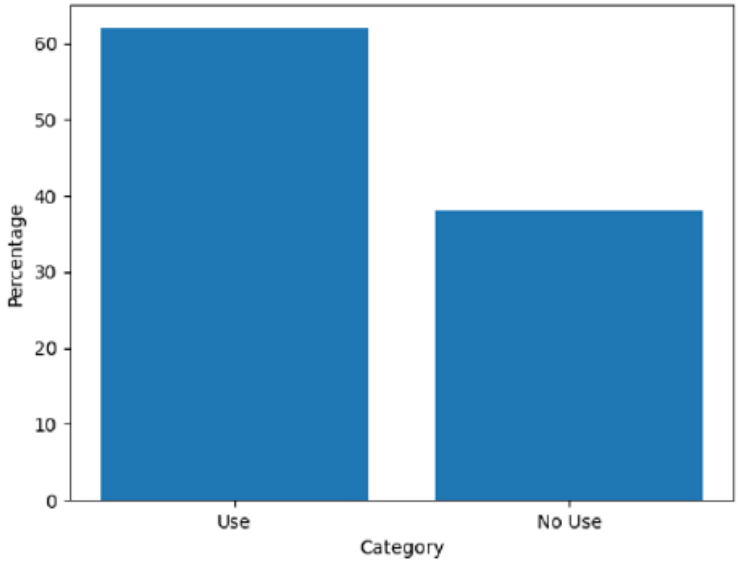


**Figure 1.** Prevalence of Use

Figure 1 illustrates the proportion of respondents who used traditional oxytocic products compared to those who did not. The figure clearly demonstrates that most women rely on traditional methods, reinforcing the high prevalence observed in Table 2.

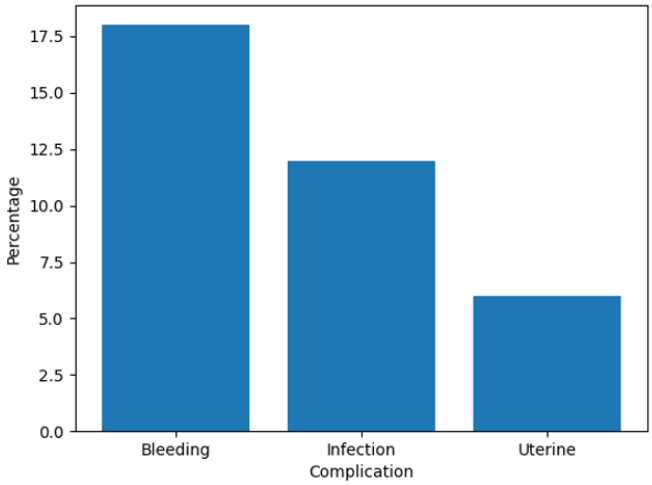


**Figure 2.** Complications

Figure 2 presents the distribution of complications associated with traditional oxytocic use. Excessive bleeding is the most reported complication, followed by infections and uterine complications. This visual representation emphasizes the clinical risks associated with these practices.

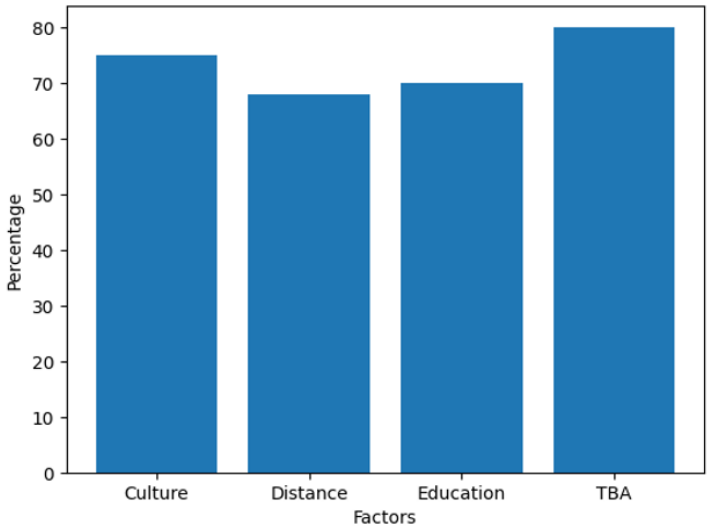


**Figure 3.** Factors Influencing Use

Figure 3 shows the relative contribution of different factors influencing the use of traditional oxytocic products. The figure highlights the dominant role of traditional birth attendants and cultural beliefs, followed by education and access-related factors, confirming the findings presented in Tables 3 and 4.

## Discussion

The findings of this study demonstrate a high prevalence of traditional oxytocic use (62%), as shown in Table 2 and illustrated in Figure 1, which is consistent with studies conducted in sub-Saharan Africa [21–30]. This high level of utilization reflects the continued reliance on traditional maternal health practices in rural settings despite the availability of modern obstetric services.

Cultural beliefs and the influence of traditional birth attendants (TBAs) emerged as strong predictors of traditional oxytocic use, as presented in Table 3 and further confirmed by the logistic regression analysis in Table 4. Notably, TBA influence showed the strongest association (AOR = 3.1; $p < 0.001$), followed by cultural beliefs (AOR = 2.8; $p = 0.001$). These findings highlight the critical role of community-level actors and socio-cultural norms in shaping maternal health decisions, emphasizing the need for culturally sensitive interventions that engage TBAs as key stakeholders.

Distance to healthcare facilities was also significantly associated with the use of traditional oxytocics, as indicated in Table 3 ($p = 0.002$) and Table 4 (AOR = 2.3; $p = 0.004$). This reflects persistent structural barriers in rural African settings, where limited access to health services compels women to seek alternative options. Women with lower levels of education were more likely to use traditional methods, as shown in Table 1, Table 3, and Table 4, which is consistent with findings from similar contexts [31–36]. Lower educational attainment may limit awareness of potential risks and reduce access to accurate health information.

The reported complications further emphasize the potential dangers associated with the unsupervised use of traditional oxytocic substances. As presented in Table 5 and visually demonstrated in Figure 2, excessive bleeding (18%) was the most reported complication, followed by infection (12%) and uterine-related complications (6%). These findings align with WHO reports linking unsafe traditional practices to increased maternal morbidity and adverse obstetric outcomes [37–40].

Additionally, Figure 3 highlights the relative contribution of different influencing factors, reinforcing the dominant role of cultural beliefs and TBA influence compared to structural and educational factors. This visual representation supports the quantitative findings and underscores the multifactorial nature of traditional oxytocic use.

Overall, the convergence of findings from Tables 1–5 and Figures 1–3 suggests that traditional oxytocic use in rural Kavango is driven by a combination of socio-cultural influences, limited healthcare access, and educational disparities. Addressing these factors requires integrated strategies that strengthen healthcare systems while also engaging community structures and cultural practices.

These findings are consistent with recent studies in sub-Saharan Africa, including Ghana, where the continued use of local oxytocic substances such as Kaligutim has been reported, with healthcare providers expressing concerns about safety, dosing, and adverse maternal outcomes [41].

## Qualitative Results (Thematic Analysis)

The qualitative component of the study provided deeper insight into the socio-cultural and structural factors influencing the use of traditional oxytocic products. Four major themes emerged from the thematic analysis:

### Theme 1: Strong Cultural Beliefs Supporting Traditional Practices

Participants consistently expressed strong cultural attachment to traditional childbirth practices. Many women reported that the use of traditional oxytocics was a long-standing practice passed down through generations.

> *"In our culture, these herbs have always been used during childbirth. Our mothers and grandmothers trusted them."*

This theme highlights the deep-rooted belief systems that normalize and promote the use of traditional oxytocics within the community.

### Theme 2: Influence and Trust in Traditional Birth Attendants (TBAs)

Traditional birth attendants were identified as key influencers in the use of traditional oxytocic products. Participants indicated that TBAs were trusted for their experience and accessibility.

> *"The traditional birth attendant knows what to give and when. We trust them more because they are part of our community."*

This reinforces the quantitative findings (Table 3 and Table 4) where TBA influence was a significant predictor of use.

### Theme 3: Barriers to Accessing Formal Healthcare Services

Limited access to healthcare facilities was a major factor influencing reliance on traditional methods. Participants reported long distances, transport challenges, and costs as barriers.

> *"The clinic is very far, and sometimes there is no transport. It is easier to use traditional medicine at home."*

This theme aligns with quantitative findings (Table 3 and Table 4) showing a significant association between distance to healthcare facilities and traditional oxytocic use.

### Theme 4: Perceived Effectiveness and Safety of Traditional Oxytocics

Many participants believed that traditional oxytocic products were effective in inducing labor and were safer than hospital-based interventions.

> *"The herbs help labor come faster, and we believe they work better than hospital medicine."*

However, some participants acknowledged risks, especially when complications occurred.

### Integration of Qualitative Findings into Discussion

The qualitative findings complement and strengthen quantitative results by providing context-specific explanations for the observed patterns of traditional oxytocic use.

Cultural beliefs emerged as a dominant factor influencing the use of traditional oxytocic products, as evidenced in both qualitative narratives and quantitative data (Table 3, Table 4, and Figure 3). The strong cultural attachment to traditional practices suggests that interventions aimed at reducing unsafe practices must be culturally sensitive and community oriented.

The influence of traditional birth attendants, highlighted in qualitative findings, further supports their role as key determinants of traditional oxytocic use. This aligns with the logistic regression results (Table 4), where TBA influence was the strongest predictor. These findings underscore the importance of integrating TBAs into formal healthcare systems through training and collaboration rather than exclusion.

Barriers to accessing healthcare services, particularly distance and transportation challenges, were consistently reported by participants and are reflected in the quantitative findings (Table 3 and Table 4). This indicates that improving physical access to healthcare facilities is critical for reducing reliance on traditional methods.

The perception of effectiveness and safety of traditional oxytocics also contributes to their continued use. Despite reported complications (Table 5 and Figure 2), many participants-maintained confidence in traditional remedies. This highlights a gap in awareness and risk communication, suggesting the need for targeted health education interventions.

Overall, the integration of qualitative and quantitative findings demonstrates that the use of traditional oxytocic products in rural Kavango is driven by a complex interplay of cultural, social, and structural factors. Addressing these issues requires a holistic approach that combines healthcare system strengthening with culturally appropriate community engagement strategies.

## Conclusion

The present study revealed a substantial level of traditional oxytocic use (62%) among women in rural communities of the Kavango region, Namibia. The findings suggest that this practice is shaped by an interplay of socio-cultural influences and structural limitations. Deeply rooted cultural beliefs and the strong influence of traditional birth attendants (TBAs) were identified as key drivers. In addition, barriers such as long distances to healthcare facilities and lower levels of education further reinforce reliance on traditional practices.

Although these substances are widely utilized, the study highlights important health risks associated with their use, including excessive bleeding, infections, and uterine complications, as demonstrated in Table 5 and Figure 2. The continued use of these practices, despite the occurrence of adverse outcomes, reflects strong community confidence in traditional systems as well as limited awareness of potential health risks.

Furthermore, the integration of both quantitative and qualitative findings indicates that traditional oxytocic use is not solely a consequence of limited healthcare access but is also deeply embedded within cultural norms and perceptions of effectiveness. This underscores the need for interventions that are not only focused on improving healthcare accessibility but are also culturally responsive and community centered.

Overall, reducing the risks associated with traditional oxytocic use will require a multifaceted approach that combines health system strengthening, targeted health education, and meaningful engagement with traditional practitioners to promote safer maternal health practices.

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## Recommendations

Based on the findings of this study, several context-specific recommendations are proposed to address the high reliance on traditional oxytocic products and improve maternal health outcomes in rural Kavango:

1. **Enhancement of Community-Based Health Education**

There is a critical need to strengthen community-focused health education initiatives aimed at increasing awareness of the potential risks associated with the unsupervised use of traditional oxytocic substances. These educational programs should be culturally sensitive, utilize locally appropriate communication strategies, and be delivered in local languages to ensure effective understanding and community engagement. Emphasis should be placed on promoting safe maternal health practices and encouraging timely utilization of formal healthcare services.

2. **Integration and Capacity Building of Traditional Birth Attendants (TBAs)**

Given their central role and strong influence within rural communities, traditional birth attendants should be actively incorporated into the formal healthcare system. This can be achieved through structured training programs, supervision, and capacity-building initiatives aimed at enhancing their knowledge of safe maternal care practices. Such integration would enable TBAs to act as key partners in promoting health education, identifying complications early, and facilitating appropriate referrals to healthcare facilities.

3. **Improving Accessibility of Maternal Healthcare Services**

Efforts should be intensified to address structural barriers that limit access to maternal healthcare in rural areas. Strategies should include the expansion and strengthening of rural health infrastructure, improvement of transportation networks to facilitate timely access to care, and the implementation of outreach and mobile health services. These interventions are essential to reducing the reliance on traditional alternatives and ensuring that women can access skilled obstetric care when needed.

4. **Policy and Health System Strengthening**

There is a need for policymakers to develop and implement clear guidelines addressing the use of traditional oxytocic substances within maternal healthcare. National and regional health policies should promote the safe integration of traditional practices into the formal health system while ensuring regulation and monitoring of potentially harmful practices. Strengthening collaboration between the Ministry of Health and traditional health practitioners is essential to improve maternal health outcomes.

In addition, policies should prioritize:

- Expansion of maternal health services in rural and underserved areas.
- Strengthening referral systems between community and health facilities.
- Incorporation of community-based maternal health programs.

Such policy-level interventions will help bridge the gap between traditional and modern healthcare systems while ensuring patient safety.

5. **Recommendations for Future Research**

Further research is necessary to deepen understanding of the use and effects of traditional oxytocic substances. Future studies should focus on:

- Identifying and analyzing the specific types and composition of traditional oxytocic products used in rural communities.
- Investigating the pharmacological effects and safety profiles of these substances.
- Assessing the long-term maternal and neonatal outcomes associated with their use.
- Evaluating the effectiveness of community-based interventions aimed at reducing unsafe practices.

- Exploring behavioral and cultural dynamics influencing maternal health decision-making.

Such research will provide critical evidence to inform policy, guide clinical practice, and support the development of culturally appropriate interventions.

## Acknowledgements

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## Ethical Approval and Consent to Participate

Ethical approval for this study was obtained from the relevant Institutional Review Board (IRB) and the Ministry of Health and Social Services (MoHSS) in Namibia. Permission to conduct the study was also obtained from local authorities in the Kavango region.

All participants provided written informed consent prior to participation. For participants below 18 years of age, consent was obtained from a parent or guardian in addition to assent from the participant. Participation was voluntary, and respondents were informed of their right to withdraw from the study at any time without any consequences.

## Consent for Publication

Not applicable. This study does not contain any individual personal data or identifying information.

## Availability of Data and Materials

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

## Competing Interests

The author declares that there are no competing interests.

## Funding

This research received no external funding and was conducted as part of independent academic work.

## Author Contribution

The author (Dr. Sebastien Njila Tshipamba) was solely responsible for conceptualization, study design, data collection, data analysis, interpretation of results, and manuscript preparation.

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# Artificial Intelligence in Regulatory Medical Writing: Opportunities, Challenges, and Implications for Clinical Trial Documentation

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***Abstract*** *Artificial intelligence (AI) is increasingly being explored in healthcare communication and scientific documentation, including applications in regulatory medical writing. Regulatory medical writing plays a critical role in the preparation of clinical trial documentation required for regulatory submissions, including clinical study reports, study protocols, investigator brochures, and safety reports. The integration of AI technologies, particularly natural language processing and machine learning, has created opportunities to improve efficiency, consistency, and workflow management in documentation-related activities. However, concerns remain regarding accuracy, transparency, ethical considerations, and regulatory compliance associated with AI-assisted documentation. This article explores the current and potential applications of artificial intelligence in regulatory medical writing and evaluates its implications for clinical trial documentation. A qualitative narrative review approach was adopted using published literature, regulatory guidance documents, and policy papers related to AI in healthcare, scientific communication, and regulatory science. The review identifies major opportunities associated with AI-assisted documentation, including automated drafting, content summarization, workflow optimization, and consistency in document preparation. At the same time, important limitations and challenges were identified, including reliability concerns, hallucination risks, lack of transparency, ethical considerations, data privacy issues, and uncertainties regarding regulatory acceptance. The review further discusses the evolving role of medical writers in an AI-assisted environment and highlights the importance of human oversight in maintaining documentation quality, scientific accuracy, and compliance with regulatory expectations. The findings suggest that while AI has significant potential to support regulatory medical writing, responsible integration requires robust governance frameworks, ethical oversight, and clear regulatory guidance.*

***Keywords*** *Artificial Intelligence, Clinical Study Reports, Clinical Trial Documentation, Natural Language Processing, Regulatory Medical Writing, Regulatory Science.*

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## Introduction

Artificial intelligence (AI) has emerged as one of the most influential technological developments in healthcare, biomedical research, and scientific communication [1, 2]. AI-driven technologies, particularly machine learning and natural language processing (NLP), are increasingly being integrated into healthcare systems to support clinical decision-making, data analysis, workflow optimization, and scientific documentation [9, 11, 12, 19, 20]. In parallel, the healthcare and pharmaceutical industries are experiencing substantial growth in digital transformation initiatives, including automation of documentation-related processes.

Regulatory medical writing is a specialized scientific discipline that supports the preparation of regulatory and clinical trial documents required throughout the drug development lifecycle. Regulatory medical writers prepare essential documents such as clinical study reports (CSRs), clinical trial protocols, investigator brochures, informed consent forms, briefing documents, and safety reports in accordance with international regulatory guidelines including International Council for Harmonisation (ICH) E3 and ICH E6(R3) Good Clinical Practice guidelines [3, 4]. These documents require high levels of scientific accuracy, consistency, traceability, clarity, and regulatory compliance.

The increasing complexity of global clinical trials and the growing volume of clinical documentation have created significant operational challenges for pharmaceutical organizations and regulatory teams. As a result, there is growing interest in exploring AI-assisted systems that may improve efficiency, reduce repetitive manual tasks, support consistency across documents, and optimize workflow management.

Recent advancements in generative AI technologies have accelerated discussions regarding their use in healthcare communication and medical writing [22-24]. AI-assisted systems are capable of performing tasks including automated drafting, language refinement, text summarization, literature screening, data extraction, and document organization [1, 2, 22-24]. These capabilities suggest potential applications within regulatory medical writing and clinical documentation.

Despite these opportunities, important concerns remain regarding the responsible use of AI in regulatory documentation. Existing literature identifies several challenges associated with AI-assisted content generation, including hallucination risks, factual inaccuracies, lack of transparency, ethical concerns, accountability issues, and uncertainties regarding regulatory acceptance [5, 6]. In clinical trial documentation, such concerns are particularly important because inaccuracies or inconsistencies may affect scientific integrity, regulatory decision-making, and patient safety.

Although AI applications in healthcare communication have been increasingly studied, limited literature specifically evaluates the role of AI in regulatory medical writing and clinical trial documentation [7, 8]. Current evidence remains fragmented, and there is limited discussion regarding how AI technologies align with regulatory expectations for scientific documentation and quality standards.

The present review article aims to explore the current and potential applications of artificial intelligence in regulatory medical writing and evaluate associated opportunities, challenges, ethical considerations, and regulatory implications for clinical trial documentation. The review further discusses the evolving role of medical writers in an AI-assisted environment and identifies areas requiring future research and governance development.

## Materials and Methods

This study employed an exploratory qualitative narrative review design based on literature review and regulatory document analysis. The methodology was selected because the objective of the study was exploratory and interpretive in nature rather than hypothesis-driven. The study focused on understanding the opportunities, challenges, and regulatory implications associated with artificial intelligence in regulatory medical writing.

### Literature Search Strategy

A narrative literature review approach was adopted to identify published literature relevant to artificial intelligence, healthcare communication, scientific writing, regulatory science, and regulatory medical writing. Literature searches were conducted using electronic scientific databases including PubMed, Scopus, and Google Scholar.

Literature published between January 2015 and March 2026 was considered for inclusion in the review. Searches were conducted between February and March 2026 to identify relevant peer-reviewed publications, regulatory guidance documents, and policy papers. The final review included publications and documents considered most relevant to the study objectives following title, abstract, and full-text assessment and evaluation against the predefined inclusion and exclusion criteria.

The following keywords and combinations were used during literature searches:

1. “Artificial intelligence in healthcare”
2. “Artificial intelligence and medical writing”
3. “AI-assisted documentation”
4. “Regulatory medical writing”
5. “Clinical trial documentation”
6. “Natural language processing in healthcare”
7. “Generative AI in scientific communication”

### Inclusion and Exclusion Criteria

The review included:

1. Peer-reviewed journal articles
2. Regulatory guidance documents
3. Policy papers
4. Published reviews related to AI in healthcare and scientific communication
5. Literature discussing ethical and regulatory considerations associated with AI.

The review excluded:

1. Non-English publications
2. Duplicate studies
3. Non-scientific opinion articles without relevant discussion
4. Publications unrelated to healthcare documentation or medical writing

### Regulatory Document Review

In addition to published literature, regulatory guidance documents and policy publications from organizations including the International Council for Harmonisation (ICH), World Health Organization (WHO), and European Medicines Agency (EMA) were reviewed to evaluate regulatory perspectives regarding AI integration and documentation quality standards.

### Data Collection and Thematic Analysis

Relevant literature and regulatory documents were reviewed and analyzed using qualitative thematic analysis. An inductive analytical approach was adopted to identify recurring themes, patterns, and relationships within the reviewed literature.

The thematic analysis focused on the following categories:

1. Applications of artificial intelligence in regulatory medical writing.
2. Benefits and opportunities associated with AI-assisted documentation.
3. Challenges and limitations.
4. Ethical and regulatory considerations.

5. Implications for clinical trial documentation.
6. Future role of medical writers.

Descriptive synthesis was also performed to evaluate trends within the reviewed literature. To enhance credibility and consistency of interpretation, themes identified across the reviewed literature were compared and synthesized across multiple sources, including peer-reviewed publications, regulatory guidance documents, and policy papers. Among the reviewed publications, the most frequently discussed themes included workflow efficiency, automation of repetitive documentation tasks, ethical concerns, reliability of AI-generated outputs, and the importance of human oversight.

## Results

The qualitative thematic review identified multiple recurring themes regarding the applications, opportunities, challenges, and regulatory implications associated with artificial intelligence in regulatory medical writing and clinical trial documentation.

A review of the included literature demonstrated increasing interest in AI-assisted technologies within healthcare communication, biomedical documentation, and scientific writing over recent years [1, 2, 8]. Most publications discussed the growing role of natural language processing, machine learning systems, and generative AI tools in supporting documentation-related activities including automated drafting, summarization, literature screening, language refinement, and workflow optimization.

Thematic synthesis further demonstrated that the reviewed literature consistently emphasized both the operational opportunities and the scientific limitations associated with AI-assisted documentation. Several publications highlighted that AI technologies may improve productivity and reduce repetitive documentation activities; however, concerns regarding scientific reliability, hallucination risks, ethical considerations, transparency, and regulatory compliance were also frequently reported.

The review additionally identified limited literature specifically focused on AI applications within regulatory medical writing when compared with broader healthcare AI literature. Most available publications discussed healthcare communication or scientific writing in general rather than regulatory documentation prepared for clinical trial submissions.

### Emerging Applications of Artificial Intelligence

The reviewed literature identified several potential applications of artificial intelligence in regulatory medical writing and clinical documentation.

The most frequently discussed applications included:

1. Automated drafting of narrative sections
2. Text summarization and synthesis
3. Literature screening and evidence identification
4. Grammar and language refinement
5. Consistency checking across documents
6. Workflow and document management support

The major applications identified through thematic analysis are summarized in Table 1.

**Table 1.** Potential Applications of Artificial Intelligence in Regulatory Medical Writing

| AI Application | Potential Role in Regulatory Medical Writing |
|---|---|
| Natural Language Processing | Text summarization and language refinement |
| Generative AI | Automated drafting support |
| Automation Tools | Workflow management and repetitive task reduction |

| | |
|---|---|
| AI Review Systems | Consistency checking and terminology alignment |
| Literature Screening Tools | Evidence identification and literature review support |

Generative AI technologies were particularly associated with drafting assistance and content organization [8]. Natural language processing systems were also reported to support extraction and summarization of large volumes of scientific information [1, 2].

Within regulatory medical writing, AI-assisted applications may potentially support preparation of:

1. Clinical study reports
2. Clinical trial protocols
3. Safety narratives
4. Investigator brochures
5. Submission summaries
6. Regulatory briefing documents

Recent advancements in artificial intelligence have also resulted in the development of multiple AI-assisted technologies relevant to healthcare documentation and scientific communication. The reviewed literature identified several categories of AI tools that may support regulatory medical writing activities.

Natural language processing systems are increasingly used for language refinement, terminology standardization, text summarization, and extraction of scientific information from large datasets [1, 2]. Generative AI systems such as ChatGPT and other large language model-based tools are capable of supporting automated drafting, content organization, and generation of narrative summaries [8, 22].

Machine learning-based systems are also increasingly explored for healthcare data analysis, predictive modeling, and workflow automation [9-11, 15]. In addition, AI-assisted literature review and document management platforms are being evaluated for evidence identification, data organization, and document workflow support.

Examples of AI-assisted technologies currently discussed or explored within healthcare and pharmaceutical industries include:

1. ChatGPT and large language model-based tools for drafting and summarization
2. Natural language processing platforms for language refinement and text extraction
3. AI-assisted literature screening tools for evidence review
4. Automation systems for workflow management and document tracking
5. AI-supported quality review systems for terminology consistency and formatting verification

Examples of AI-assisted technologies relevant to regulatory medical writing are summarized in Table 2.

**Table 2.** Examples of AI Tools Relevant to Regulatory Medical Writing

| **AI Tool** | **Primary Function** | **Potential Regulatory Writing Application** |
|---|---|---|
| ChatGPT | Generative AI | Drafting support and summarization |
| Claude | Large Language Model | Document review and content refinement |
| Gemini | Multimodal AI | Information synthesis and drafting support |
| Microsoft Copilot | Productivity AI | Workflow support and content generation |
| Elicit | Literature Review AI | Evidence identification and |

| | | |
|---|---|---|
| | | literature screening |
| Consensus | Research Search AI | Scientific evidence retrieval |
| Covidence | Review Platform | Literature screening and review management |
| DistillerSR | Systematic Review Platform | Evidence management and document review |

The reviewed literature also identified growing interest in AI-assisted quality review tools that may support:

1. Consistency checking
2. Grammar review
3. Template standardization
4. Terminology alignment
5. Cross-document verification

However, the reviewed literature consistently emphasized that these technologies should function as supportive tools under human oversight rather than independent systems for regulatory decision-making or scientific interpretation.

The findings suggest that AI-assisted technologies may be most beneficial in repetitive and process-oriented documentation tasks, while higher-level scientific interpretation and regulatory judgment continue to require human expertise. The reviewed literature consistently identified repetitive documentation activities, workflow management, language refinement, and content summarization as the most frequently reported areas of potential AI application within regulatory medical writing.

## Opportunities Associated with AI-Assisted Documentation

The reviewed literature consistently identified operational efficiency as one of the major opportunities associated with AI integration in healthcare documentation [1, 2]. AI-assisted systems were reported to support faster drafting, improved workflow management, and reduction of repetitive manual activities.

Several publications suggested that AI technologies may contribute to:

1. Improved documentation efficiency
2. Faster turnaround timelines
3. Enhanced consistency across documents
4. Better organization of large datasets
5. Standardization of terminology and formatting
6. Support for literature review activities

The key opportunities and challenges identified from the reviewed literature are summarized in Table 3.

**Table 3.** Opportunities and Challenges Associated with AI-Assisted Documentation

| **Opportunities** | **Challenges** |
|---|---|
| Improved efficiency | Hallucination risks |
| Faster document drafting | Factual inaccuracies |
| Workflow optimization | Ethical concerns |
| Consistency support | Regulatory uncertainty |
| Reduction in repetitive tasks | Data privacy concerns |

Thematic analysis also indicated that AI-assisted systems may become increasingly valuable because of the growing complexity and volume of clinical trial documentation generated during modern drug development programs.

Another recurring theme involved workflow optimization. Automation technologies were associated with potential improvements in project management, document tracking, version control, and cross-functional collaboration.

The literature additionally suggested that AI may support medical writers by reducing administrative burden and allowing greater focus on scientific interpretation, strategic communication, and quality review.

## Regulatory and Ethical Concerns

Regulatory and ethical considerations emerged as major themes throughout the reviewed literature and regulatory guidance documents [5, 6, 14]. Several publications emphasized that clinical trial documentation requires high standards of scientific accuracy, data integrity, traceability, and regulatory compliance.

The review identified multiple concerns regarding the use of AI-assisted systems in regulatory medical writing, including [13]:

1. Hallucination risks and fabricated information
2. Lack of transparency in AI-generated outputs
3. Potential bias in generated content
4. Data privacy and confidentiality concerns have been widely discussed in healthcare AI literature
5. Inaccurate interpretation of scientific information
6. Uncertainty regarding accountability and authorship

Several studies evaluating generative AI systems have emphasized the importance of human validation because AI-generated outputs may contain inaccuracies, fabricated content, and context-dependent errors [23].

Regulatory guidance documents including ICH E3 and ICH E6(R3) emphasize the importance of accurate, traceable, and quality-controlled clinical documentation [3, 4]. These principles are highly relevant to AI-assisted documentation because inaccuracies or inconsistencies may affect regulatory decision-making and patient safety.

The World Health Organization guidance on ethics and governance of artificial intelligence for health further highlights the importance of transparency, accountability, human oversight, and ethical governance in healthcare AI applications [5, 21]. Similarly, the European Medicines Agency reflection paper discusses the need for governance frameworks, validation procedures, and regulatory oversight for AI integration within the medicinal product lifecycle [6].

The thematic review demonstrated that current regulatory frameworks remain limited regarding the acceptable use of generative AI in regulatory medical writing and clinical documentation. Existing literature therefore emphasizes the need for development of:

1. AI governance frameworks
2. Validation procedures
3. Quality control standards
4. Human review requirements
5. Documentation auditability standards
6. Regulatory guidance specific to AI-assisted documentation

## Future Role of Medical Writers

The reviewed literature consistently suggested that artificial intelligence is unlikely to replace regulatory medical writers entirely but may augment documentation workflows and scientific communication processes [24]. Instead, AI technologies are more likely to function as supportive tools that assist with repetitive and administrative documentation tasks.

The findings indicate that medical writers will continue to play critical roles in:

1. Scientific interpretation
2. Clinical and regulatory judgment
3. Quality assurance
4. Contextual understanding
5. Strategic communication
6. Regulatory compliance review

Several publications emphasized that AI-generated outputs require careful review and validation by qualified subject matter experts because AI systems currently lack contextual reasoning and independent scientific judgment [1, 2].

The literature also suggests that future medical writers may require additional competencies related to AI-assisted workflows, prompt engineering, validation of AI-generated content, and digital literacy [22-24].

Overall, the findings indicate that future regulatory medical writing environments are likely to involve increasing collaboration between human expertise and AI-assisted technologies rather than complete automation.

## Discussion

The present narrative review identified growing interest in the application of artificial intelligence within healthcare communication and scientific documentation. Existing literature demonstrates that AI-assisted technologies have potential applications across multiple aspects of regulatory medical writing, particularly in repetitive and process-oriented documentation tasks.

The findings suggest that AI-assisted systems may improve operational efficiency and workflow management by supporting automated drafting, text summarization, consistency checking, and content organization [1, 2]. The thematic review further indicated that AI-assisted technologies may be most beneficial in repetitive and process-oriented documentation activities, including drafting support, content summarization, workflow management, and document standardization. These findings support the view that AI is currently best positioned as a supportive technology rather than a replacement for scientific expertise and regulatory judgment.

One of the most significant findings from the review was the potential role of AI in reducing repetitive manual activities associated with documentation preparation. Clinical trial documentation often involves large volumes of standardized content and repetitive formatting processes. AI-assisted technologies may support faster document preparation and improved productivity while enabling medical writers to focus on higher-level scientific interpretation and quality review.

The review also identified important concerns regarding the use of AI-assisted systems in regulatory documentation. Hallucination risks, factual inaccuracies, lack of transparency, and potential bias in generated outputs were among the most frequently discussed limitations [5, 6]. These concerns are particularly important in regulatory medical writing because clinical trial documentation directly supports regulatory decision-making and patient safety.

Another major theme identified in the literature was the importance of human oversight. The reviewed publications consistently emphasized that AI-generated outputs require scientific review and validation by qualified professionals. AI technologies currently lack contextual understanding, scientific judgment, and regulatory interpretation capabilities required for independent preparation of high-quality regulatory documentation [16-19].

The findings further indicate that regulatory frameworks governing AI-assisted documentation remain underdeveloped. Current regulatory guidance documents do not yet provide comprehensive direction regarding the acceptable use of generative AI tools such as ChatGPT or other large language model-based systems within clinical trial documentation workflows. Although organizations such as WHO and EMA have published broader guidance related to AI governance and healthcare applications, limited guidance specifically addresses AI-assisted regulatory medical writing and clinical trial documentation [21]. This creates uncertainty regarding acceptable practices, validation standards, auditability requirements, and accountability for AI-generated content.

The evolving role of medical writers also emerged as an important discussion point.

Rather than replacing medical writers, AI is more likely to function as a supportive technology that enhances productivity while human experts continue to provide scientific interpretation, regulatory oversight, quality assurance, and strategic communication.

The review identified several areas requiring future research, including evaluation of AI-assisted drafting systems, assessment of quality review platforms, validation of AI-generated outputs, comparison between AI-assisted and traditionally authored documentation, assessment of documentation quality outcomes, and development of governance frameworks for responsible AI integration within regulated documentation environments.

## Study Limitations

The present review was based on narrative literature review and qualitative thematic analysis rather than systematic review methodology. Therefore, findings should be interpreted within the context of exploratory qualitative research. In addition, literature specifically focused on AI in regulatory medical writing remains limited because this is an emerging area of research.

## Conclusion

Artificial intelligence represents an important technological advancement with increasing applications in healthcare communication and scientific documentation. The findings from this review suggest that AI-assisted technologies may support regulatory medical writing through automated drafting, text summarization, workflow optimization, and consistency support.

The review identified several potential benefits associated with AI-assisted documentation, including improved operational efficiency, reduction of repetitive manual tasks, enhanced workflow management, and support for large-scale documentation processes. These opportunities may become increasingly relevant as clinical trials continue to generate substantial volumes of complex scientific information.

However, the review also identified significant concerns associated with AI integration in regulatory documentation, including hallucination risks, factual inaccuracies, lack of transparency, ethical considerations, data privacy concerns, and uncertainties regarding regulatory acceptance. Because clinical trial documentation directly influences regulatory decision-making and patient safety, maintaining scientific integrity and documentation quality remains critically important.

The findings further demonstrate that human oversight remains essential in AI-assisted regulatory medical writing. Medical writers continue to play a central role in scientific interpretation, quality assurance, contextual understanding, and regulatory compliance.

Overall, the study highlights the need for responsible integration of artificial intelligence into regulatory medical writing practices through governance frameworks, validation procedures, ethical oversight, and clear regulatory guidance. Future empirical research is required to evaluate the practical implementation and long-term impact of AI-assisted technologies within clinical trial documentation environments.

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## Data Availability Statement

No primary datasets were generated or analyzed during the current study. All information used in this review was obtained from publicly available published literature, regulatory guidance documents, and policy papers cited within the manuscript.

## Author Contributions

The Corresponding author was solely responsible for the conceptualization, literature review, data collection, thematic analysis, interpretation of findings, manuscript preparation, and final approval of the submitted article.

## Conflict of Interest

The author declares no conflict of interest.

## Ethical Approval

Ethical approval was not required for this study because it was based exclusively on published literature, regulatory guidance documents, and publicly available sources. No human participants, patient data, or animal subjects were involved in the conduct of this research.

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# A Comparative Study of Synthesized Berberine-Iron Oxide Nanoparticles and Cisplatin: Characterization and Biological Applications

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***Abstract*** *Non-small cell lung cancer (NSCLC) remains one of the leading causes of cancer-related deaths worldwide due to its high incidence, aggressive progression, and limited treatment options. Although cisplatin-based chemotherapy is a standard treatment for NSCLC, its clinical use is hindered by severe side effects and drug resistance. To address these challenges, the present study focused on the green synthesis of berberine-loaded iron oxide nanoparticles (BBR-FeONPs) using Phyllanthus amarus as a natural reducing and stabilizing agent. The formation of BBR-FeONPs was indicated by a visible color change and confirmed through characterization techniques, including UV-visible spectroscopy, FTIR, XRD, SEM, TEM, and zeta potential analysis. UV-vis spectroscopy showed a surface plasmon resonance peak at 335-342 nm, while FTIR identified functional groups involved in nanoparticle stabilization. XRD confirmed their crystalline structure, and SEM/TEM analyses revealed spherical and oval-shaped particles with an average size of 52 ± 2 nm. Zeta potential analysis (-8.50 mV) indicated moderate colloidal stability. Antimicrobial assays showed dose-dependent inhibition zones against S. aureus (13.0 mm), E. coli (14.3 mm), and P. aeruginosa (15.0 mm). In vitro cytotoxicity studies demonstrated enhanced anticancer activity of BBR-FeONPs against H460 NSCLC cells ($IC_{50}$=34.27 ± 2 µg/mL) compared to BBR, FeONPs, and cisplatin, with lower toxicity toward HEK-293 normal cells. Wound healing assays showed significant anti-migratory activity (6.14% at 200 µg/mL). These findings suggest that BBR-FeONPs are a promising and safer alternative for NSCLC treatment. Further studies are needed to explore their molecular mechanisms, assess in vivo toxicity, and evaluate biodistribution profiles.*

***Keywords*** *BBR-FeONPs, Berberine, Cisplatin, FeONPs, Wound Healing*.

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## Introduction

Lung cancer is the most commonly occurring cancer around the world [1, 2]. According to the Indian Council of Medical Research's National Cancer Registry Programme, the incidence of cancer in India is expected to rise from approximately 1.46 million cases in 2022 to 1.57 million by 2025, indicating a rising trend in the national cancer burden [3]. In India, metropolitan cities reported high lung cancer prevalence; Mizoram has the highest reported increasing lung cancer rates for both men and women when compared to Chennai, Delhi, and Bengaluru [4]. The major risk factors for lung cancer include occupational exposure to carcinogens such as asbestos, silica, air pollution, and genetic mutations; additionally, a high intake of processed meats and alcohol has been linked to an increased risk of developing lung cancer [5, 6]**.** Currently, NSCLC treatment options include both surgical interventions and non-surgical therapies such as radiation therapy, chemotherapy, targeted therapy, and immunotherapy. However, these approaches have often shown limited effectiveness due to a major challenge in drug resistance [7].

In recent years, nanotechnology has played an important role in enhancing NSCLC treatment, particularly in overcoming drug resistance. Nanoparticles can carry cancer-related drugs directly to tumour cells, reducing side effects and increasing therapeutic efficacy. Additionally, they help to overcome resistance mechanisms by improving drug uptake and retention within cancer cells [8, 9]. Among the various methods, green synthesis has gained more significant attention due to its environmentally friendly, budget-friendly, and biocompatible nature. Plant-based nanoparticles show promising anticancer activity when compared to chemically synthesized nanoparticles [10].

Recently, studies have highlighted the green synthesis methods of metal and metal oxide nanoparticles, such as silver (AgNPs), gold (AuNPs), and iron oxide (FeONPs), demonstrating their potential for sustainable and eco-friendly applications in various biomedical and industrial fields [11]. A traditional Indian Medicinal plant, like *P. amarus*, belonging to the *Euphorbiaceae* family, contains various therapeutic and phytochemical properties, such as flavonoids, polyphenols, and alkaloids, which act as natural reducing and stabilizing agents in the synthesis of nanoparticles [11, 12]. Several studies have confirmed that biologically synthesized FeONPs exhibit anti-inflammatory, anti-cancer, and antioxidant properties against cancer cells by generating reactive oxygen species (ROS), impairing mitochondrial function, and activating apoptotic pathways. Furthermore, FeONPs enhance bioavailability and cellular uptake, offering a biocompatible and cost-effective platform for targeted cancer therapy. The synthesis of *P. amarus-mediated* FeONPs in cancer treatment supports sustainable nanotechnology for therapeutic nanocarriers with dual diagnostic and treatment in lung cancer [13].

Berberine is a widely used natural product of quinoline alkaloid compounds primarily derived from various plants of Berberis [14]. It contains several phytochemical components that contribute to its diverse pharmacological applications, including chemoprotective, hepatoprotective, antidiabetic, antibacterial, antioxidant, anti-inflammatory, and antiviral effects [15]. Researchers have recently explored plant-based compounds such as berberine, which has demonstrated strong anticancer activity by targeting multiple oncogenic pathways. However, their clinical application is hindered by low bioavailability and poor absorption. To overcome these limitations, nanotechnology-based drug delivery systems, such as iron oxide nanoparticles, offer a promising approach to enhance the therapeutic effectiveness of berberine [16].

Cisplatin is a chemotherapy drug widely used to treat various cancers such as lung,

ovarian, testicular, and head and neck cancers [17]. The main action of cisplatin in lung cancer is to bind to DNA to prevent replication, inducing the formation of ROS, activating DNA repair mechanisms, arresting the cell cycle, and stimulating apoptosis [18]. However, it has some limitations, including toxicity-related side effects and producing drug resistance, which can impact overall effectiveness on non-small cell lung cancer treatment [17].

In the present study, the main aim is to formulate green-synthesized BBR-FeONPs using an eco-friendly approach, and it was characterized and evaluated for their biological activity, such as anti-cancer and anti-migratory effects against non-small cell lung cancer (NSCLC-H460) and normal human embryonic kidney (HEK-293) cell lines compared with the standard chemotherapeutic drug cisplatin. Additionally, the antimicrobial activity of BBR-FeONPs was assessed against clinical pathogens, including *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*.

## Materials and Methods

### Green Synthesis of Iron Oxide Nanoparticles using Phyllanthus Amarus Extract

The *P. amarus* plant was obtained from the Tada local market in Andhra Pradesh, India, and authenticated (1026.10122401) at the Siddha Central Research Institute, Chennai. The plant was properly washed and cleaned with double-distilled water, cut into smaller pieces, air-dried, and powdered using a manual grinder. A 1000 mg powdered sample was boiled in 100 mL of double-distilled water at 60°C for 2 hours, and the solution was filtered through Whatman No. 1 filter paper and stored at 4°C for further use. Ferric chloride ($FeCl_3$-20 mmol) was dissolved in 50 mL of double-distilled water. The *P. amarus* extract was mixed with the $FeCl_3$ solution in a 1:1 ratio and incubated at 40°C for 48 hours, on an orbital shaker at 250 rpm, maintaining pH between 7.35 to 7.45.

### Biosynthesis of Berberine-Loaded Iron Oxide Nanoparticles (BBR-FeONPs)

0.1 mg of berberine chloride (BBR-Cl) was dissolved in 1.5 mL of dimethyl sulfoxide (DMSO) and subsequently diluted with 3.5 mL of phosphate buffer saline (PBS) to obtain a 5 mL berberine chloride solution. The solution was vortexed for 15 minutes and then stirred on a magnetic stirrer for 1 hour. The prepared solution was mixed with FeONPs in a 1:1 ratio and subjected to sonication for 30 minutes. The final solution was oven-dried at 35°C for 5 hours, and the dried powdered sample was stored at room temperature.

### Characterization of BBR-FeONPs

The synthesized berberine-loaded iron oxide nanoparticles (BBR-FeONPs) were characterized using analytical techniques. UV–Visible spectroscopy (Shimadzu UV-1900i, Japan) was performed in the 200–700 nm range to confirm nanoparticle formation. Functional groups were identified using Fourier Transform Infrared (FT-IR) spectroscopy (Josvok FTIR-1500, China) within the 4000–400 $cm^1$ range. X-ray diffraction (XRD, Bruker, Germany) with Cu-Kα radiation (2θ = 20–80°) was used to confirm the crystalline structure of the synthesized nanoparticles. The surface morphology was analysed using a scanning electron microscope (SEM, Carl Zeiss Sigma 300). High-resolution transmission electron microscopy (HR-TEM, Thermo Fisher F200S) was used to determine the size, shape, and structural features of the nanoparticles. The zeta potential was measured using a Zeta sizer (Malvern Instruments, ZS Explorer v4.0, UK) to evaluate the surface charge and stability of the nanoparticles.

### Antibacterial Activity of BBR-FeONPs

The antibacterial efficacy of berberine-conjugated iron oxide nanoparticles (BBR-FeONPs) was evaluated using the agar well

diffusion method against *Escherichia coli*, *Streptococcus aureus*, and *Pseudomonas aeruginosa*. The bacterial strains were obtained from the Central Research Laboratory, Meenakshi Academy of Higher Education and Research (MAHER), Chennai, India. Fresh bacterial cultures were prepared in sterile peptone water and incubated at 37 °C for 18 hours in an orbital shaker incubator at 120–150 rpm. Mueller-Hinton Agar (MHA) plates were prepared, and wells of 6 mm diameter were created into the agar using a sterile 200 µL pipette tip. Each well was loaded with 200 µL of BBR-FeONPs at concentrations of (0, 50, 100, and 150 µg/mL). Amoxicillin was used as a positive control. The plates were incubated at 37 °C for 24 hours, after which the zone of inhibition (in mm) was measured using a digital antibiotic zone reader to determine antibacterial activity.

## In Vitro Biocompatibility Analysis

### Cell Culture

Non-small cell lung cancer cell lines (H460) and human embryonic kidney (HEK-293) cell lines were obtained from the National Centre for Cell Science (NCCS), Pune, India. Cell lines were grown in Dulbecco's Modified Eagle's Medium (DMEM) with heat-inactivated 10% (FBS) and 5% penicillin-streptomycin (10,000 U/mL) at 37°C under a 5% $CO_2$ supply in a humidified atmosphere until cell growth reached 80% confluence.

### Cytotoxicity Assay

The cytotoxic effects of FeONPs, BBR, BBR-FeONPs, and cisplatin were evaluated in H460 non-small cell lung cancer (NSCLC) cells and HEK-293 human embryonic kidney cells using the MTT assay. Cells ($7\times10^3$ cells/well) were seeded in a 96-well plate and incubated at 37°C in a humidified atmosphere containing 5% $CO_2$ for 24 hours to allow for cell attachment. Following incubation, cells were treated with different concentrations (0, 25, 50, 75, 100, 125, 150, 175, and 200 µg/mL) of the test compounds and incubated for an additional 24 hours. Untreated cells served as the control group. After treatment, the culture medium was discarded, and 100 µL of fresh medium was added to each well, followed by the addition of 10 µL of MTT reagent and the plate was incubated for 4hours at 37 °C. Subsequently, 100 µL of sodium dodecyl sulphate (SDS) solution was added to each well and the plates were further incubated for 4–18 hours at 37 °C. The absorbance was then measured at 570 nm using an ELISA microplate reader (iMARK Bio-reader, Model No. 21154). All experiments were conducted in triplicate. The percentage of cell inhibition was measured using the following formula: Cell Viability (%) = (OD of test sample) / (OD of control) × 100 [19].

### Wound Healing Assay

The migratory capacity of H460 non-small cell lung cancer (NSCLC) cells was evaluated using a wound healing (scratch) assay. $5 \times 10^6$ cells were seeded into 6-well plates and incubated at 37 °C in a humidified atmosphere containing 5% $CO_2$ for 24 hours until the cells reached approximately 85–90% confluence. A sterile 200 µL micropipette tip was used to create a uniform scratch in the cell monolayer. Detached cells were gently removed by washing with phosphate-buffered saline (PBS). Subsequently, cells were treated with various concentrations of BBR-FeONPs (0.25, 50, 100, and 200 µg/mL). Cisplatin (200 µg/mL) served as a positive control. The plates were incubated at 37 °C, and wound closure was measured at 0, 24, and 48 hours using a phase-contrast microscope (Accu-Scope, EXI310F, USA). All experiments were performed in triplicate. The percentage of wound closure (relative cell migration) was calculated using image analysis software by comparing the wound area at each time point relative to the initial wound area.

### Statistical Analysis

Analysis of data was carried out with SPSS Statistics v19. Continuous variables

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are presented as Mean ± SD. Normality of data was evaluated through the Shapiro-Wilk test. Parametric tests were utilized, with paired t-tests for intra-group analysis and one-way ANOVA for inter-group analysis. Significance was determined at $p < 0.05$. All experiments were performed in triplicates ($n = 3$).

## Results

### Biosynthesis and Physicochemical Characterization of BBR-FeONPs

The aqueous extract of *Phyllanthus amarus* was employed for the green synthesis of iron oxide nanoparticles (FeONPs), functioning as both a reducing and stabilizing agent. As shown in Figure 1. The visible colour transition from pale yellow to dark brown confirms the formation of FeONPs. The synthesized FeONPs were subsequently conjugated with berberine to produce berberine-loaded iron oxide nanoparticles (BBR-FeONPs) [20].

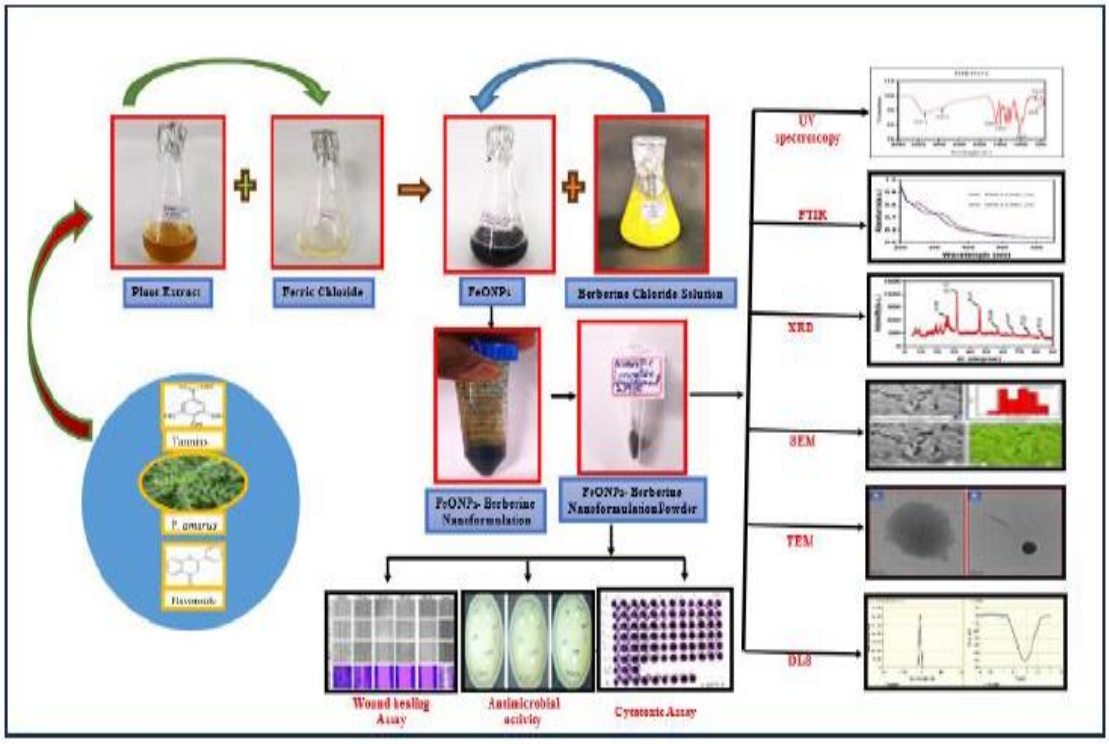


**Figure 1.** Synthesis of P. Amrus Mediated BBR-FeONPs

The characterization of BBR-FeONPs was investigated using UV-visible spectroscopy. The absorption spectra of FeONPs displayed a distinct peak around 275–285 nm, corresponding to the surface plasmon resonance (SPR) of iron oxide nanoparticles. The increased intensity and a slight redshift in the peak at 48 hours compared to 1 hour indicate progressive nanoparticle formation and stabilization. Upon conjugation with berberine, BBR-FeONPs exhibited characteristic absorption peaks at 335–342 nm, attributed to π–π* electronic transitions of berberine. The observed redshift in the 6-hour sample compared to the 1-hour sample suggests successful interaction and conjugation of berberine with FeONPs, as shown in Figure 2 [21].

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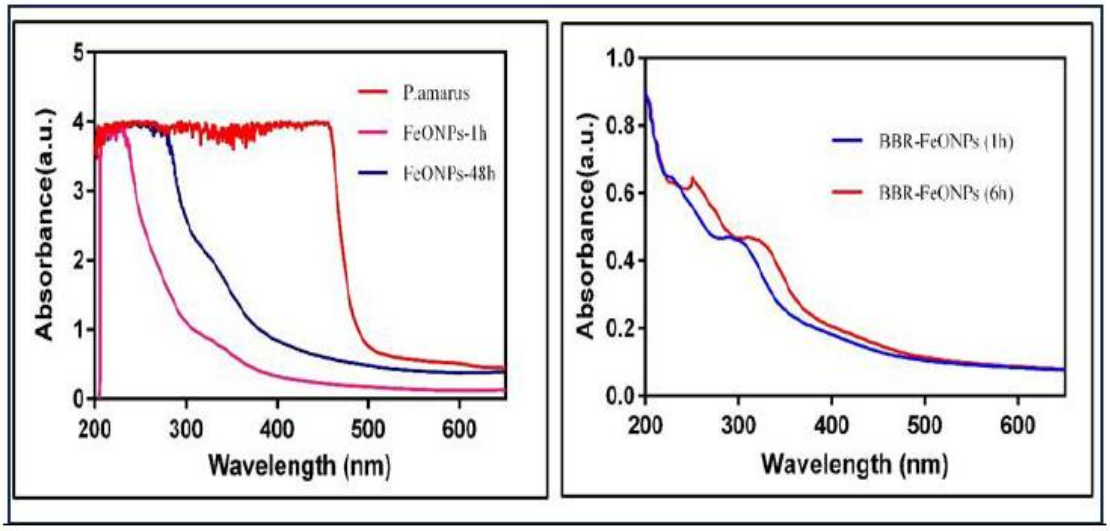


**Figure 2.** UV–Visible Spectroscopy of BBR-FeONPs

Fourier Transform Infrared (FTIR) spectroscopy was employed to confirm the functional groups involved in the FeONPs with berberine Figure 3. A broad absorption band at 3335.9 $cm^{-1}$ corresponds to O–H stretching vibrations from hydroxyl groups, indicating the presence of phenolic or alcoholic compounds from berberine and *Phyllanthus amarus* extract. The peak at 2996.6 $cm^{-1}$ is attributed to C–H stretching of aliphatic chains. Peaks at 1601.5 $cm^{-1}$ and 1520.2 $cm^{-1}$ correspond to C=C aromatic ring stretching, characteristic of the berberine structure. The bands at 1361 $cm^{-1}$ and 1280.5 $cm^{-1}$ are assigned to C–H bending vibrations of alkyl groups. A prominent band at 1040.2 $cm^{-1}$ indicates C–O stretching, suggesting the involvement of alcohol, ether, or phenolic groups. The absorption peak at 621.3 $cm^{-1}$ confirms the Fe–O stretching vibration, indicating the formation of iron oxide nanoparticles. These findings validate the successful capping and stabilization of FeONPs by berberine.

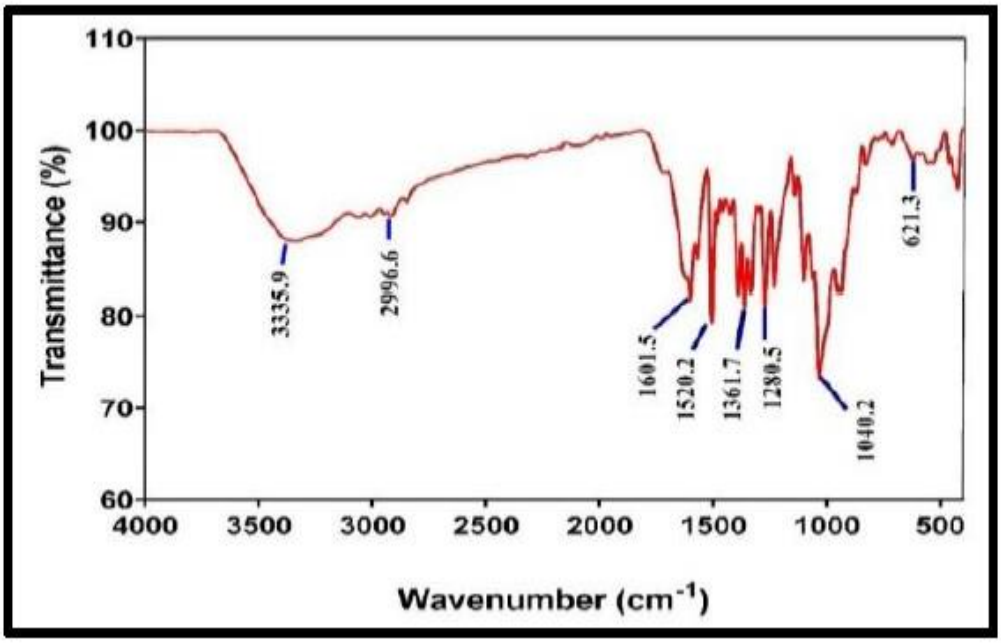


**Figure 3.** Fourier Transform Infrared Spectroscopy (FTIR) of BBR-FeONPs

The crystalline structure of BBR-FeONPs was analysed using X-ray diffraction (XRD), as shown in Figure 4. The diffraction pattern exhibited distinct peaks at 2θ values of 29.48°, 33.72°, 46.41°, 58.44°, 66.89°, 76.23°, and 85.23°, corresponding to the crystallographic planes (100), (101), (102), (103), (110), (112), and (201), confirming the crystalline nature of the nanoparticles. The most intense peak at 33.72° (assigned to the (101) plane) was used to calculate the average crystallite size using the Debye–Scherrer equation, yielding an approximate size of 16.51 nm.

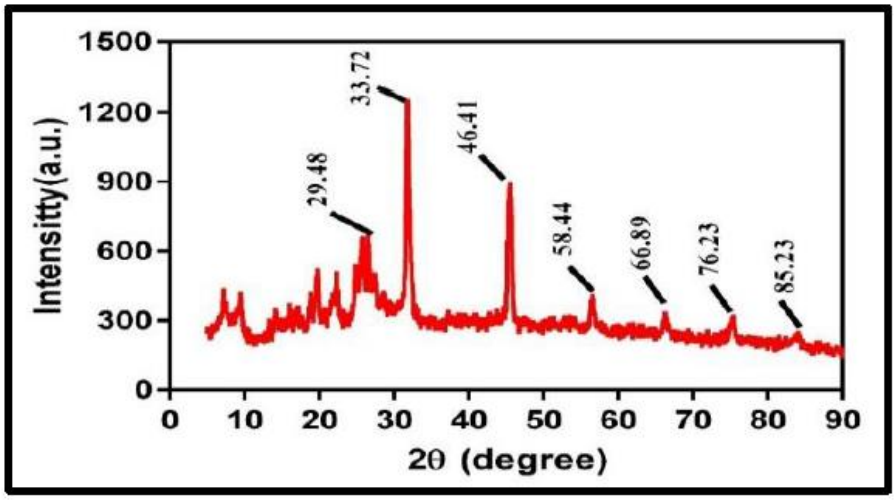


**Figure 4.** Energy Dispersive X-ray Spectrometry of BBR-FeONPs

Additionally, the XRD profile revealed a mixed-phase composition, with 30.9% crystalline and 69.1% amorphous content, indicating partial ordering within the BBR-FeONPs matrix. This dual-phase structure may contribute to the unique physicochemical properties of the nanoconjugate.

Scanning Electron Microscopy (SEM) revealed that the BBR-FeONPs possess a predominantly spherical morphology with an irregular and rough surface, likely due to successful berberine conjugation Figure 5. The particles appeared agglomerated, with a size distribution ranging from 21 to 84 nm, and an average particle size of approximately 52 nm.

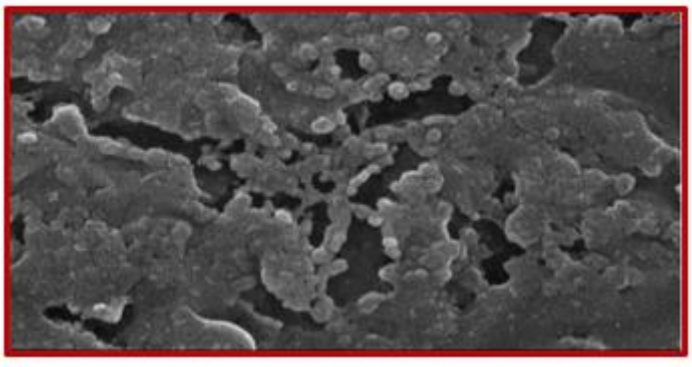

**Figure 5.** Scanning Electron Microscope of BBR-FeONPs

Transmission Electron Microscopy (TEM) confirmed the nanoscale morphology of BBR-FeONPs, revealing their spherical shape with well-defined boundaries, as shown in Figure 6. These observations support the uniformity and structural stability of the synthesized nanoparticles.

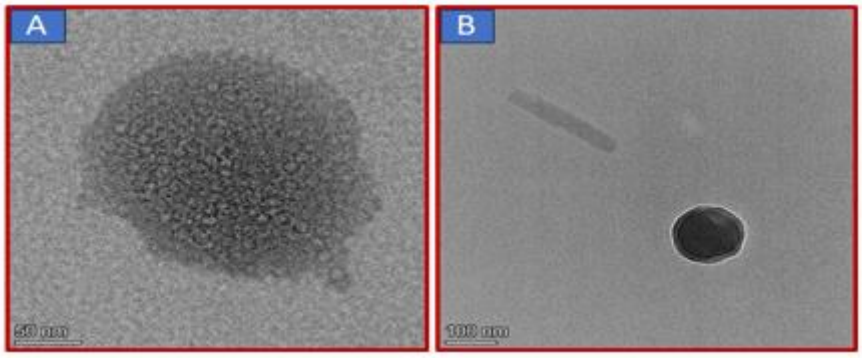


**Figure 6.** Transmission Electron Microscope of BBR-FeONPs.

Zeta potential analysis was performed to evaluate the surface charge and colloidal stability of BBR-FeONPs. As presented in Table 1, the nanoparticles exhibited a surface charge of -8.3 mV, with a zeta deviation of 4.157 mV, indicating low variability in particle charge. These results, supported by the zeta potential distribution profile shown in Figure 7 and corresponding parameters listed in Table 2, confirm the formation of a moderately stable colloidal dispersion with a uniform charge distribution.

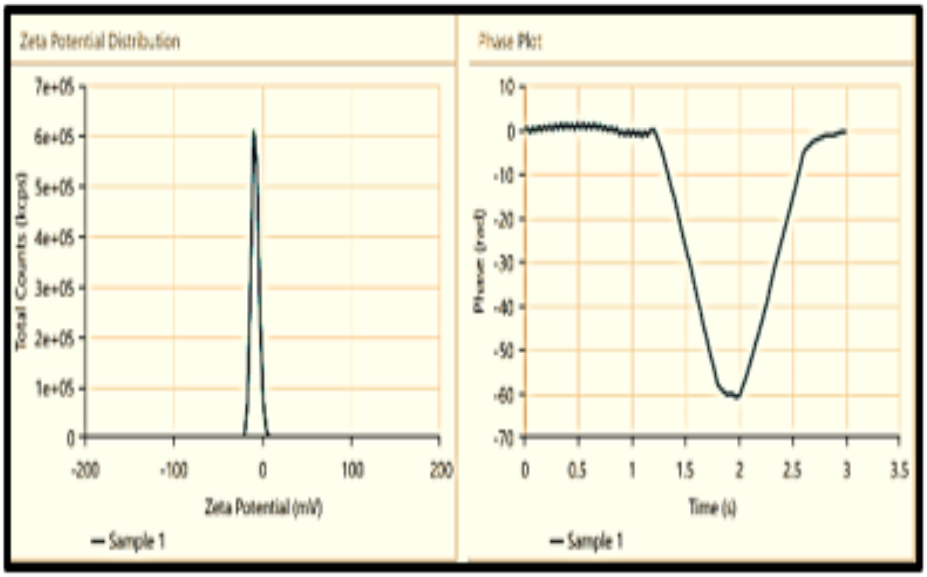


**Figure 7.** Zeta Potential Measurement of Green Synthesis of BBR-FeONP

**Table** 1. Specifications for Measuring the Zeta Potential

| **Zeta potential measurement of BBR-FeONPs** | |
|---|---|
| Zeta Potential (mV) | -8.303 |
| Zeta Peak 1 Mean (mV) | 0.1538 |
| Wall Zeta Potential (mV) | -8.709 |
| Zeta Deviation (mV) | 4.157 |
| Derived Mean Count Rate (kcps) | 1.565E+05 |
| Reference Beam Count Rate (kcps) | 2298 |
| Quality Factor | 3.437 |

**Table 2.** Conditions for Zetapotential Measurements

| **Conditions for Zeta Potential Measurements** | |
|---|---|
| Dispersant Name | Water |
| Dispersant RI | 1.33 |
| Viscosity (cP) | 0.887 |
| Dispersant Dielectric Constant | 78.5 |
| Temperature (°C) | 25 |
| Cell Description | Zeta DTS1070 |
| Derived Mean Count Rate (kcps) | 1.565E+05 |
| Reference Beam Count Rate (kcps) | 2298 |

## Quantification of Drug Encapsulation and Loading in BBR-FeONPs

The encapsulation efficiency (EE) and drug loading (DL) of the synthesized BBR-FeONPs were found to be approximately 76% and 7.3%, respectively. These values indicate a high degree of berberine entrapment within the iron oxide nanoparticle matrix.

## Antimicrobial Activity of BBR-FeONPs

The current study proved that the antimicrobial activity of BBR-FeONPs was evaluated against *Staphylococcus aureus, Pseudomonas aeruginosa,* and *Escherichia coli* and was determined using the agar well diffusion method, with amoxicillin used as a positive control. The results demonstrated that a clear concentration dose-dependent zone of inhibition was observed across all tested bacterial strains. At the lowest tested concentration (50 µg/mL), BBR-FeONPs showed moderate antimicrobial zones of inhibition of 8 mm, 12.5 mm, and 11 mm against *S. aureus, E. coli*, and *P. aeruginosa,* respectively. Increasing concentration (150 µg/mL) produced zones of inhibition of 13 mm, 15 mm, and 14.3 mm for *S. aureus, E. coli*, and *P. aeruginosa*. Notably, *P. aeruginosa* significantly exhibited the highest zone of inhibition at different concentrations of BBR-FeONPs and showed high antimicrobial activity compared to the other strains. Amoxicillin showed the highest zones of inhibition across all organisms, with diameters of 16.6 mm, 14 mm, and 13 mm for *S. aureus, P. aeruginosa,* and *E. coli* Figure 8.

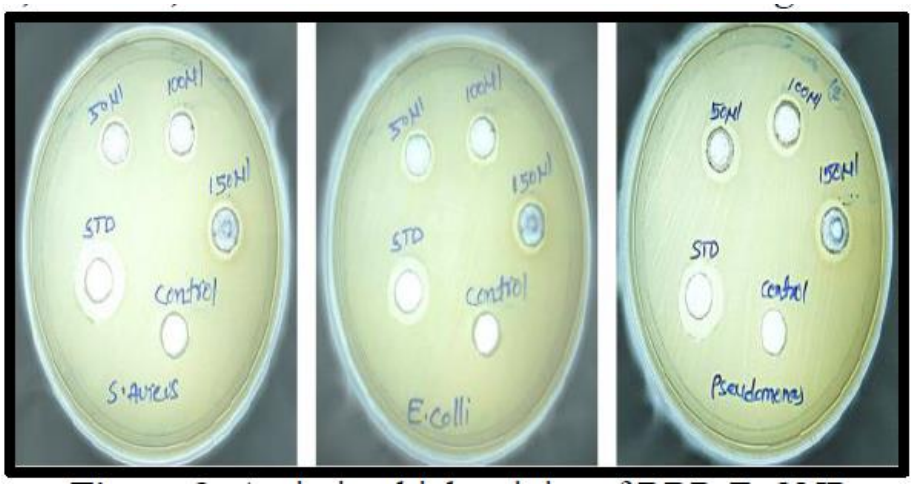


**Figure 8.** Antimicrobial Activity of BBR-FeONPs

Overall, these findings highlight the promising concentration-dependent antibacterial potential of BBR-FeONPs, particularly against Gram-negative pathogens, and it is statistically significant and p<0.01 Table 3.

**Table 3.** BBR-FeONPs Comparison of Zone of Inhibition Based on Drug Concentrations and Type of Organisms

| BBR-FeONPs Drug Concentrations | S. aureus | | P. aeruginosa | | E. coli | | p-value |
|---|---|---|---|---|---|---|---|
| | Mean | S.D | Mean | S.D | Mean | S.D | |
| **Amoxicillin** | 16.6667 | 0.57735 | 14 | 1 | 13 | 1 | 0.005* |
| **50 µg/mL** | 8 | 1 | 12.5 | 1 | 11 | 1 | 0.01* |
| **100µg/mL** | 12 | 1 | 13 | 0.70711 | 12 | 1 | 0.2 |
| **150 µg/mL** | 13 | 1 | 15 | 1 | 14.3333 | 1.52753 | 0.19 |
| **p-value** | 0.01* | | 0.01* | | 0.01* | | |

*One Way ANOVA test; *p-value<0.05- statistically significant*

## Evaluation of the Cytotoxic Effects of BBR-FeONPs on H460 Non-Small Cell Lung Cancer and HEK293 Human Embryonic Kidney Cells

The cytotoxic potential of synthesized FeONPs, BBR, BBR-FeONPs, and cisplatin was evaluated using the MTT assay on H460 (NSCLC) and HEK-293 cell lines. In H460 cells, FeONPs exhibited a concentration-dependent cytotoxic effect, ranging from 5.16% at 25 µg/mL to 61.29% at 200 µg/mL. BBR, from 9.68% at 25 µg/mL to 74.19% at 200 µg/mL. Notably, the combination of BBR-FeONPs showed enhanced cytotoxicity from 14.19% at 25 µg/mL to 90.97% at 200 µg/mL. Cisplatin, used as a positive control, exhibited 16.16% at 25 µg/mL to 68.39% at 200 µg/mL. All tested compounds demonstrated a clear dose-dependent inhibition, as shown in Figure 9. The mean and SD values of IC50 have been given in Table 4, along with the 95% Confidence Interval. There was a significant difference was observed in IC50 values among all groups (p-value 0.01). However, BBR-FeONPS had a significantly lower $IC_{50}$ value than all other drugs, as shown in Figure 10.

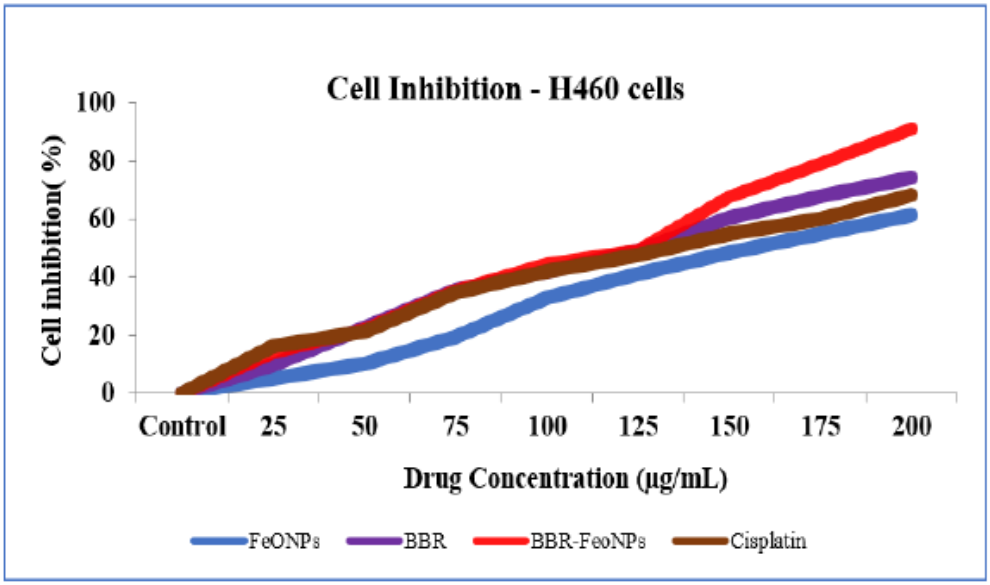


**Figure 9.** Comparison of Cell Inhibition of FeONPs, BBR, BBR-FeONPs, and Cisplatin on H460 Cells based on Different Concentrations (p-value<0.001; One Way ANOVA test)

https://doi.org/10.21522/TIJAR.2014.13.03.Art007

**Table 4.** Comparison of $IC_{50}$ Values

| | **$IC_{50}$value Mean+SD** | **95% Confidence Interval** | **p-value** |
|---|---|---|---|
| **FeONPS** | 58.5+2.1 | 52.71-61.2 | **0.01*** |
| **BBR** | 41.98+4.0 | 37.65-45.75 | |
| **BBR-FeONPS** | 34.27+2.0 | 31.50-36.41 | |
| **Cisplatin** | 36.44+3.22 | 35.20-37.50 | |

*One Way ANOVA test; *p-value<0.05- statistically significant*

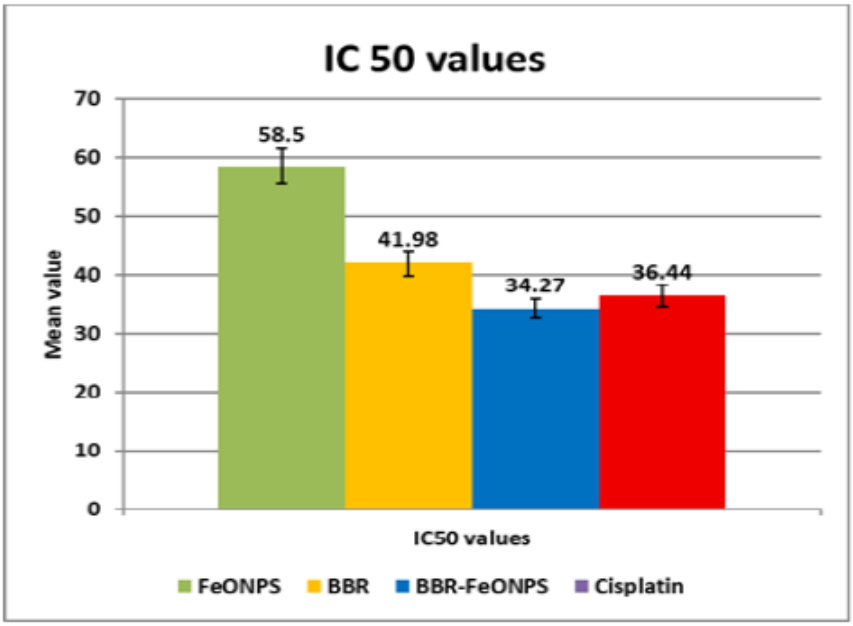


**Figure 10.** $IC_{50}$ Values of FeONPs, BBR, BBR-FeONPs, and Cisplatin Against H460 Cells

In HEK-293 cells, FeONPs, BBR, and BBR-FeONPs exhibited minimal cytotoxicity, whereas cisplatin demonstrated the highest cytotoxicity at a concentration of 200 µg/mL in 68.39% cell inhibition, as shown in Figure 11.

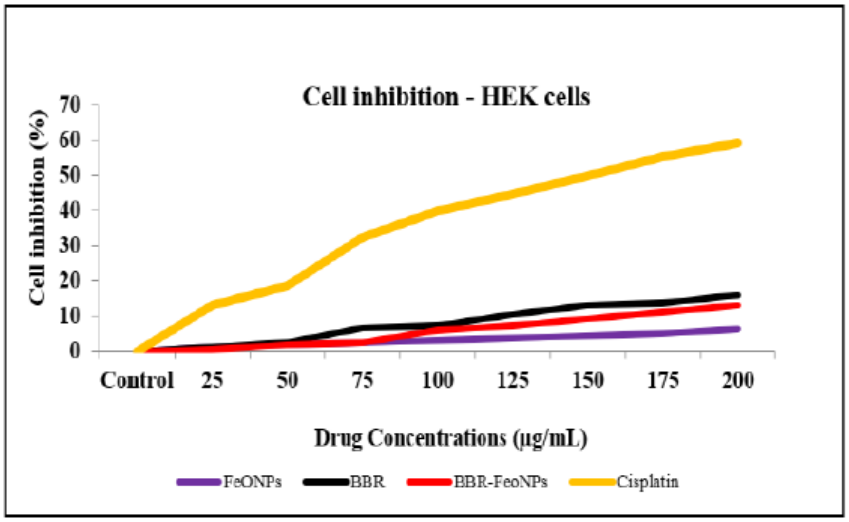


**Figure 11.** Comparison of Cell Inhibition of FeONPs, BBR, BBR-FeONPs, and Cisplatin on HEK Cells based on Different Concentrations

https://doi.org/10.21522/TIJAR.2014.13.03.Art007

## Wound Healing Assay of BBR-FeONPs used in H460 Cells

The anti-migratory effect of BBR-FeONPs on H460 NSCLC cells was assessed using a scratch wound-healing assay, as illustrated in Figure 12.

Our results explained that in the control group, cells exhibited the highest percentage of wound closure, indicating natural cell migration. In contrast, treatment with BBR-FeONPs resulted in significant, concentration-dependent inhibition of cell migration. At a lower concentration of 10 µg/mL, BBR-FeONPs reduced wound closure to 15.99%, indicating a mild inhibitory effect. As the concentration increased, a marked reduction in cell migration was observed: 9.92% at 50 µg/mL, 9.32% at 100 µg/mL, and 6.14% at 200 µg/mL, reflecting a clear dose-dependent inhibition of wound healing. Cisplatin at 200 µg/mL exhibited 9.51% wound closure, which was comparable to the effect of BBR-FeONPs at 100 µg/mL, but significantly less effective than BBR-FeONPs at 200 µg/mL.

Statistical analysis confirmed that the mean wound closure percentage for 200 µg/mL BBR-FeONPs was significantly lower ($p < 0.05$) than that of all other treatment groups, including cisplatin, indicating a superior anti-migratory effect. No statistically significant difference was observed between BBR-FeONPs (100 µg/mL) and cisplatin (200 µg/mL), suggesting a comparable anti-migratory potential at these concentrations Table 5.

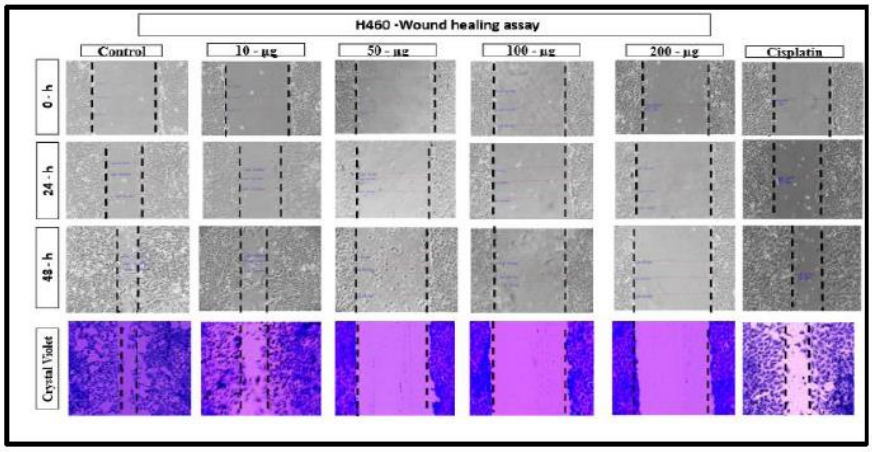


**Figure 12.** Wound Healing Assay of H460 Cells Treated with BBR-FeONPs and Cisplatin

**Table 5.** Migration Distance (Mean ± SD) of H460 Cancer Cells Treated with BBR-FeONPs and Cisplatin at Three Time Points

| **Migration Distance (M+S.D)** | | | | |
|---|---|---|---|---|
| **Concentrations** | **0 h ($T_1$)** | **24 h ($T_2$)** | **48 h ($T_3$)** | **p-value[a] (0 hr vs 48 hour)** |
| **Control** | 2230.67+0.0 | 1574.67+35.6 | 1086.33+23.45 | 0.001* |
| **25 µg/mL** | 2230.67+0.0 | 1678.67+52.3 | 1318.33+34.2 | 0.01* |
| **50µg/mL** | 2230.67+0.0 | 1789.67+56.7 | 1465.67+43.2 | 0.01* |
| **100µg/mL** | 2230.67+0.0 | 2012.32+32.1 | 1989.23+75.2 | 0.32 |
| **200µg/mL** | 2230.67+0.0 | 2121.67+27.8 | 2012.68+67.8 | 0.31 |
| **Cisplatin** | 2230.67+0.0 | 1798.58+34.5 | 1415.23+56.0 | 0.01* |
| **p-value[b]** | 1 | 0.01* | 0.01* | |

[a]Paired t-test; *p-value<0.05 –statistically significant; [b]One Way ANOVA test; *p-value<0.05 –statistically significant

## Discussion

Iron oxide nanoparticles (FeONPs) were successfully synthesized using the aqueous extract of *Phyllanthus amarus*, which acts as both a natural reducing and stabilizing agent. The synthesized BBR-FeONPs were visually confirmed by the colour change from yellow to dark brown, indicating the successful formation of nanoparticles. The presence of bioactive phytochemicals in the extract, such as phenolics, flavonoids, and carotenoids, played a crucial role in reducing metal ions and acting as a capping agent on the nanoparticles, thereby enhancing their stability. Similar findings have been shown in earlier studies [13, 20].

The use of a green synthesized iron oxide nanoparticle approach is an environmentally friendly, biocompatible, improves drug efficacy and reduces systemic toxicity in cancer therapy. Iron oxide nanoparticles act as magnetic carriers, improving the targeted delivery of berberine to tumour sites, thereby increasing intracellular drug concentration. This targeted delivery not only enhances the therapeutic efficacy of berberine but also minimizes damage to surrounding healthy tissues, making it a promising strategy for cancer treatment [22-24].

The characterization techniques, like UV-Visible Spectroscopy, FTIR, XRD, SEM, TEM, and zeta potential, further validate the formation of BBR-FeONPs. The UV-Visible Spectroscopy observed a peak around 335-342 nm, indicating the successful formulation of berberine-conjugated iron oxide nanoparticles. Similarly, previous studies have reported that Berberine nanoparticles (BBR NPs) exhibited a peak at 344nm [25-27]. FTIR analysis further confirmed the structural integrity and functional group interactions within the synthesized BBR-FeONPs. Characteristic absorption bands corresponding to functional groups such as O–H, C–H, C=C, and Fe-O were observed at approximately 3422, 2366, 1648, 1096, and 625–600 $cm^{-1}$, respectively. These findings are reported in previous studies [26]. The identified functional groups confirm the successful capping and stabilization of iron oxide nanoparticles by phytochemicals in *P. amarus*, indicating their dual role in reducing metal ions and stabilizing the nanoparticles. This supports the efficiency and confirmation of the synthesis of nanoparticles. The crystalline nature of the synthesized BBR-FeONPs was confirmed by XRD analysis. Characteristic diffraction peaks at 2θ values around 30°, 35°, 43°, 57°, and 63° were observed, closely matching the standard patterns of $Fe_3O_4$ nanoparticles, thereby validating the successful formation of crystalline iron oxide structures [28].

Morphological analysis using SEM and TEM revealed that the synthesized BBR-FeONPs exhibited a predominantly spherical morphology with an irregular and rough surface, likely due to the surface conjugation of berberine. The average particle size was approximately 52 nm, and slight agglomeration was observed. These findings are consistent with previous reports, where FeONPs synthesized through green methods showed particle sizes ranging from 19 to 40 nm and similar spherical morphology [29]. Earlier studies demonstrated that FeONPs coated with chitosan via both chemical and biological synthesis methods exhibited spherical morphology with an average size of 42.8 nm [30].

Zeta potential analysis indicated that the BBR-FeONPs carried a surface charge of -8.3 mV, suggesting moderate colloidal stability of the nanoparticle suspension. The negative surface charge is likely due to the presence of bioactive phytochemicals acting as capping agents during green synthesis. These findings are consistent with previous studies, including biogenically synthesized FeONPs from *Leptolyngbya* sp., which exhibited a similar zeta potential of -8.5 mV [21]. Similar studies reported zeta potential values of about -19.5 mV, indicating the stable nanoparticle suspensions under physiological conditions

[31]. The observed negative charge contributes to electrostatic repulsion between particles, minimizing aggregation and enhancing dispersion stability.

The anti-microbial activity of BBR-FeONPs was exhibited, dose-dependent, zone of inhibition, against *Pseudomonas aeruginosa, Escherichia coli*, and Staphylococcus aureus. Among them, *P. aeruginosa* has demonstrated the highest sensitivity. This outcome aligns with the initial hypothesis that BBR-FeONPs would exhibit enhanced antimicrobial activity, particularly against Gram-negative bacteria. Compared to the standard drug, BBR-FeONPs showed significant antimicrobial potential, particularly at higher concentrations. This suggests a promising therapeutic role of BBR-FeONPs as alternatives to antibiotics, especially in the antimicrobial resistance.

The observed antibacterial effect is likely attributed to the synergistic action of berberine and iron oxide nanoparticles has reported to disrupt bacterial membranes, induce cytoplasmic leakage, and promote the generation of reactive oxygen species (ROS), leading to oxidative stress and irreversible damage to vital cellular components such as DNA, proteins, and lipids [32, 33]. These mechanisms culminate in bacterial cell death, providing a plausible explanation for the strong bactericidal activity observed in this study. Previous research has shown that the antimicrobial efficacy of berberine-based nanoparticles has concentration-dependent inhibitory zones against *Methicillin-resistant Staphylococcus aureus* (MRSA) and *Escherichia coli* [27]. Overall, BBR-FeONPs showed strong potent antimicrobial activity against multidrug-resistant pathogens.

The cytotoxicity assessment using the MTT assay demonstrated that BBR-FeONPs exhibited significantly enhanced anticancer activity against H460 non-small cell lung cancer (NSCLC) cells compared to FeONPs, BBR alone, and compared to the standard chemotherapeutic agent cisplatin. All tested compounds showed dose-dependent cytotoxicity; however, BBR-FeONPs induced the highest reduction in cell viability, 90.97% at 200 µg/mL, which was statistically significant ($p < 0.01$). In contrast, FeONPs, BBR, and cisplatin exhibited comparatively lower cytotoxic effects against H460 cells, highlighting the superior efficacy of the nano-formulated BBR-FeONPs. Notably, in HEK-293 normal human kidney cells, BBR-FeONPs demonstrated minimal cytotoxicity, whereas cisplatin showed the highest toxic effect at elevated concentrations. These observations are consistent with previous reports, where berberine dose-dependent cytotoxicity in A549 ($IC_{50} = 58.33 \pm 4.96$ µM) and SKOV-3 cancer cells, while showing negligible toxicity in HEK-293 cells [34, 37]. Similarly, FeONPs showed an $IC_{50}$ of $69 \pm 0.50$ µg/mL in A549 cells [35], and berberine-loaded nanoparticles (BBR-MNPs) exhibited notable cytotoxicity in MDA-MB-231 cells [36]. Furthermore, cisplatin cytotoxicity in HEK-293 cells has been attributed to oxidative stress-mediated mitochondrial damage [38]. Overall, the present findings and existing literature suggest that BBR-FeONPs represent a promising, safer, and more effective alternative to conventional chemotherapy in lung cancer treatment.

The enhanced cytotoxic potential of BBR-FeONPs can be attributed to the synergistic mechanisms contributed by both berberine and iron oxide nanoparticles, which target multiple cellular pathways involved in cancer progression. This enhanced cytotoxicity suggests a synergistic interaction between berberine and FeONPs, likely resulting from multiple complementary mechanisms such as berberine-induced apoptosis via mitochondrial membrane depolarization, activation of caspase-3, modulation of pro- and anti-apoptotic genes (↑Bax, ↓Bcl-2), and inhibition of key survival pathways (PI3K/Akt and MAPK/ERK) [15, 16, 34, 35]. FeONPs contribute to cytotoxicity by generating reactive oxygen species (ROS), which cause

oxidative stress, lipid peroxidation, mitochondrial dysfunction, and DNA fragmentation in cancer cells. By combining these actions, it is intensified to impair cellular repair mechanisms more effectively than either agent alone, confirming the potent synergistic cytotoxic effect of the BBR-FeONP nanocomplex [13, 35].

The wound healing assay results demonstrated that BBR-FeONPs effectively inhibited cell migration in a dose-dependent manner, supressing the anti-migratory efficacy of cisplatin at higher concentrations in H460 cells. The significant reduction in wound closure at 200 µg/mL (6.14%) compared to cisplatin (9.51%) highlights the superior ability of BBR-FeONPs to suppress cellular motility. This enhanced inhibition may be attributed to the synergistic interaction of berberine and FeONPs in disrupting migration-related signalling pathways. Moreover, previous studies have shown that berberine inhibits cell migration in A549, H460, and H1299 NSCLC cell lines in a dose-dependent manner, confirming its inhibitory effect on lung cancer progression [34]. Additionally, berberine significantly inhibited wound closure in HT-29 cells, suggesting that it suppresses the cancer cell migration and metastasis [39].

## Conclusion

The green synthesized berberine-loaded iron oxide nanoparticles (BBR-FeONPs) using *Phyllanthus amarus* demonstrated excellent physicochemical stability, potent antimicrobial activity, and anticancer efficacy against H460 NSCLC cells. Furthermore, normal cells (HEK-293) showed low toxicity compared to cisplatin. The anti-migratory effect of BBR-FeONPs was observed as a minimal wound closure compared to the control groups and cisplatin. Overall, these findings highlight that the formulated BBR-FeONPs act as a promising, biocompatible nanoplatform for targeted lung cancer therapy in NSCLC. Further in vivo and mechanistic studies are warranted to validate their clinical applicability.

## Author Contributions

M.S. and D.N contributed to conceptualization, methodology, review, and editing. M.S., M.B., performed the experiments and collected the data. M.S., and T.H.H drafted the manuscript G.A.

and D.N. supervised the study and provided technical guidance. M.S. and M.B. performed the statistical analysis. All authors interpreted the results and critically reviewed and revised the final manuscript.

## Acknowledgments

Nil.

## Conflict of Interest

Nil.

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## Ethical Approval

All experimental procedures involving cell lines were conducted in accordance with institutional research guidelines. As the study involved only established cell lines and did not include human participants or animals, formal ethical committee approval was not required.

## Data Availability

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

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# Leveraging Syndromic Surveillance of Surgical Site Infections to Improve Infection Prevention and Control in Tanzania: A Quasi Experimental Study

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***Abstract*** *Surveillance of surgical site infection (SSI) is key for improving Infection Prevention and Control (IPC). In Tanzania, it is unclear how primary health facilities (PHFs) that perform syndromic surveillance of SSI differ from those that do not. This quasi-experimental study, conducted from September to November 2024, evaluated how PHFs implementing syndromic surveillance differ in IPC adherence from those that do not. The quantitative sample included 905 surgical patients from surveillance conducting PHFs and 600 from non-conducting facilities. Results demonstrated that facilities practicing syndromic surveillance achieved significantly higher IPC adherence scores, with a mean of 400.1 (SD 138.9) compared to 263.1 (SD 99.88) in the control group. This marked difference of 137 points proved statistically significant (SE 54.12; CI 23.29–250.71; unpaired t = 2.5313; P < 0.0209). For the qualitative, researchers interviewed 49 Quality Improvement Team (QIT) members to triangulate the quantitative data. These sessions were transcribed verbatim on the same day and analyzed using NVivo version 20.2, utilizing a hybrid deductive and inductive coding approach. Reported via consolidated criteria for reporting qualitative research, the analysis generated four core themes. Participants reported that syndromic surveillance is a highly valuable tool for identifying operational gaps, understanding the true infection burden, and actively strengthening facility wide IPC measures. Ultimately, these findings provide suggestive evidence that syndromic surveillance directly aids in reducing surgical site infections. Because establishing surveillance systems improves care quality, the authors recommend that all healthcare facilities should monitor for healthcare-associated infections, including SSIs, to protect patient safety.*

***Keywords*** *Healthcare Associated Infections, Infection Prevention and Control, Surgical Site Infection, Syndromic Surveillance.*

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## Introduction

Surgical Site Infections (SSIs) account for about 20% of all healthcare-associated infections (HAIs) globally. While the average infection rate in high-income countries hovers around 1% to 3%, rates in low- and middle-income countries (LMICs) frequently exceed 10%. The global status of SSIs is characterized by this stark geographic divide and the growing challenge of antimicrobial resistance. The overall pooled global incidence rate for SSIs is approximately 2.5% [1, 2]. In settings like the US and the European Union, SSI incidence sits at 1% to 5%, though these infections still contribute to hundreds of thousands of extra hospital days and massive healthcare costs. In many parts of the world, up to 10% to 25% of patients who undergo surgery acquire an SSI. According to World Health Organization (WHO) data, the African Region historically reports the highest incidence, often exceeding 7.2% in pooled analyses, and up to 20% for specific procedures like caesarean sections [3, 4].

Inadequate access to sterile instruments, operating room ventilation systems, and safe water supplies are some of the issues surrounding the high magnitude of SSIs in low- and mid-income countries including Tanzania. The spread of resistant bacteria significantly complicates treatment, increases morbidity, and prolongs recovery. Many regions lack the robust surveillance required to accurately track and manage wound complications. Tanzania has established Syndromic Surveillance to track Surgical Site Infections from the patients who have undergone surgical intervention. Syndromic surveillance describes techniques that depend on identifying observable markers of community and individual health before formal diagnoses by diagnostic tests are established [5]. Specifically, individuals who are ill may show behavioral patterns, symptoms, indicators, or laboratory findings that can be monitored using a range of data sources, even before an infectious disease is confirmed in the laboratory [6]. Systems for syndromic surveillance are being developed at the local, regional, and national levels.

The primary focus of syndromic surveillance is to aid in the early identification of a disease, research, clinical care, general public health, quality improvement, and patient safety [7]. Syndromic surveillance is a useful early warning system for epidemic diseases. Such experience suggests that syndromic surveillance systems are not only feasible but also essential for the early identification of HAIs including SSI with potential health consequences. [8]. By tracking SSI rates and identifying specific areas where they are occurring, syndromic surveillance provides concrete data that can be used to improve IPC practices. This data can be used to identify areas where HCWs may be struggling with compliance and to tailor training and support accordingly. The process of implementing and monitoring syndromic surveillance itself can raise awareness among HCWs about the importance of IPC measures and the potential consequences of non-compliance. This heightened awareness can translate into better adherence to recommended practices.

When healthcare facilities track SSI rates and share this information, it can create a sense of accountability among HCWs. Knowing that their actions are being monitored can motivate them to take infection prevention seriously and comply with IPC guidelines. Tanzania is using syndromic surveillance to document and report Surgical site Infections (SSIs) as one type of HAIs. There are three SSI indicators which are being followed in Tanzanian syndromic surveillance namely, SSIs from cesarian section and SSI other than from cesarian section both operated in the reporting facility as well as all SSIs from patients operated from other facilities if referred. The reporting in done through District Health Information System 2 (DHIS2), which is an electronic system for routine data reporting in health facilities of Tanzania [9].

A total of 117 health facilities as of December 2023 are reporting in DHIS2. Data is being recorded daily in the registers and in each month the data is summarized onto the data set, which ultimately yields the proportion of patients that experienced SSIs in DHIS2. The syndromic surveillance shows the burden and trends of SSIs in the reporting health facilities. One of the areas which may be the cause of SSIs in the health facilities is inadequate compliance of infection prevention and control (IPC) measures.

The WHO defines IPC as a practical, evidence-based approach of preventing patients and health workers from being harmed by avoidable infections [10]. Effective IPC implementation requires ongoing activities from the whole healthcare system and all stakeholder's participation, including policy makers, facility managers, healthcare workers (HCWs), patients and community in general. Morbidity and mortality due to infection and sepsis may result from non-adherence to IPC. Additionally, without an efficient IPC measure, it is impossible to guarantee the provision of safe healthcare [11]. All facets of healthcare quality are impacted by effective IPC. In low- and middle-income countries (LMICs) specifically in the PHFs where the majority of people seek their health services, secondary infections may have a detrimental impact on medical hygiene standards, patients' health and the delivery of healthcare, hence programs to support IPC are especially crucial [12].

Also, efficient IPC measures are crucial because everybody has potential to carry infectious microbes and therefore, it is necessary to presume that all bodily fluids, including blood, can spread infection. The work procedures necessary to accomplish a minimal degree of IPC are known as standard precautions. The goal of using standard precautions is to reduce and, if feasible, completely eradicate the risk of infection, especially blood-borne infections. [13]. All patients, regardless of their diagnosis or suspected infection status, are subject to standard precautions. Standard precautions include cleaning of hands before and after handling patients, using gloves, impermeable gowns, plastic aprons, masks, face shields, and eye protection, using and disposing of sharp objects safely, Standard precautions are the minimum IPC practices that must be used at all times for all patients in all situations.

Healthcare workers in healthcare facilities where syndromic surveillance is being conducted are more likely that they comply with IPC measures because data from the surveillance will give them an alarm. It will also give some clue of the source of the infection which will again help them to take informed decision from the data on how to prevent the infection. Adherence to IPC will reduce chances of HAIs including SSIs to surgical patients. Hence, this study aims at comparing between PHFs that conduct syndromic surveillance and those which do not on IPC compliance PHCs of Tanzania.

## Materials and Methods

### Data Sources

The data source was from surgical registers and from Quality Improvement Teams (QIT) members. We extracted data from operating theatre and inpatient registers as well as interviewing the QIT members. We gathered the data from September, October and November 2024 in the selected PHFs of the Tanzania. These selected PHFs were sampled from all zones of Tanzania and a total of ten (10) out 26 regions were selected. Out of 10 regions five were those which conducted syndromic surveillance of SSI and the remain did not conduct the surveillance. From 10 regions, two PHFs were selected from each region to make 20 nationally representative PHFs and eventually the surgical patients from this level of health system of Tanzania. We had managed to collect a total of 1505 surgical patents. We excluded surgical patients with missing data, we also dropped some variable

(education and marital status of the patients) that had no data in the registers. However, the missing data and the dropped variables could not affect the power of the study. Data was also obtained from interview of HCWs using the guiding question tool.

## Study Design

We conducted quasi-experimental study with both quantitative and qualitative to determine the effect of implementing Syndromic Surveillance of SSIs on IPC compliance. In quantitative part, we compared PHFs that conducted SSIs syndromic surveillance to controls PHFs that do not conduct. IPC assessment was conducted using WHO IPCAF tool in both intervention and control groups to determine the level of IPC measures compliance. The qualitative study, in-depth interviews (IDI) with health facility quality improvement teams as Key Informants were conducted using developed guiding questions.

## Study Setting

The study was conducted at PHFs of Tanzania which it is located in the Eastern part of Africa. Tanzania has 26 Regions, 139 districts, 184 councils and 12,319 villages and more than 11,000 health facilities [14]. According to sampling done, the regions sampled as intervention group were Ilala (Mnazimmoja & Chanika hospitals), Lindi (Mtama & Nachingwea District Hospitals), Kagera (Muleba&Ngara district hospitals), Kigoma (Kasulu Tc& Uvinza district Hospitals) and Mbeya (Kyela&Tukuyu District Hospitals). Also, the control regions were Arusha (AICC and Nkoalonga Hospitals at district level), Morogoro (Kilosa&Gairo District hospitals), Shinyanga (Kishapu &Kahama District hospitals), Pwani (Bagamoyo & Rufiji District Hospitals) and Singida (manyoni&Kiomboi district Hospitals). These Districts Represent all Zones of Tanzania Mainland.

## Study Population

The study group was surgical patients in selected PHFs who underwent surgery in September, October and November 2024 months. Study participants comprised of 905 from facilities that conduct SSI syndromic surveillance cases and 600 controls classified in the PHFs that do not conduct SSI. The other study population were PHFs represented by Quality Improvement Teams (QITs) from both groups and were participated for IPC compliance assessment and interview for the qualitative part. We recruited cases and controls into the study using the following definitions.

## Intervention Group Definition

We defined an intervention group as surgical patients who were attended in September, October and November 2024 from the selected PHFs where syndromic surveillance was conducted and had complete data in the operating theatre register.

## Control Group Definition

We defined a control group as surgical patients who were attended in September, October and November 2024 from the selected PHFs where syndromic surveillance was not conducted and had complete data in the operating theatre register. Identification of cases and recruitment of controls.

## Selection Criteria

### Inclusion

1. All surgical patients from PHFs in selected PHFs with complete data on SSIs in September, October and November 2024.
2. All patients undergoing any of the surgical procedures were eligible for inclusion in the surveillance even if the procedure was performed as an emergency, or if it was not the original, or main reason for surgery, e.g., abdominal hysterectomy performed due to complications during an explorative laparotomy.

3. All Members of QITs who were at Health Facility during the day when data collection was done as representatives of the PHFs which have theaters and conducted surgery**.**

**Exclusion Criteria**

1. All surgical patients from PHFs with non-open surgery and those with incomplete data of the previous three months in the time of data collection.
2. Procedures performed by endoscopy or laparoscopy. These procedures have a different risk of developing SSI and a short length of post-operative stay. Some laparoscopic-assisted bowel, bile duct and liver and vascular procedures where part of the procedure is performed endoscopically but the procedure is completed via an incision are included.
3. Procedures where primary closure of the incision is not completed in theatre (except cardiac surgery). For example, debridement and drainage of hematoma.
4. Diagnostic procedures performed in the operating theatre, e.g., biopsy, gastroscopy, aspiration, injection, or catheterization.
5. All PHFs with no theater or have not done surgeries in the past three months in the time of data collection.

## Identification of Cases and Recruitment of Controls

We collected data through PHFs document reviews specifically operating theatre registers and interviews for the QIT members using an extraction form for the secondary data structured questionnaire [15] for the assessment of the facilities to determine the IPC compliance as well as the interview to gather opinion regarding the syndromic surveillance. We selected 600 controls versus 905 of the cases with the estimate ratio of one is to two. This happened just by chance because of the number of surgical cases that met inclusion criteria between the control group and that of the cases. We also interviewed QIT members to determine their perception, thinking and experience in effect of SSI syndromic surveillance on the improvement of IPC in the PHFs.

## Study Instrument and Data Collection Techniques

We used extraction tool for secondary data, WHO IPCAP questionnaire for quantitative data and guiding question tool for qualitative data. All tools were translated in the Swahili language to interview HCWs both in intervention and in control PHFs. The extraction tool captured variables for the socio demographic information for surgical patients and the characteristics of the PHFs. The questionnaire captured socio-demographic information of the QIT members. Most of the extraction tool and questionnaire contents were adapted and adopted from previous studies on similar contexts and WHO tool.

Socio-demographic information for the surgical patients sought from participants included age, sex, Ownership (Public or Private), distance from referral hospital (50 km and below or >50 km), and place of residence (rural or urban). The extraction tool also, captured the characteristics of the PHFs namely Availability of HCWs as per MoH establishment, Availability of the patients attended both as out or in patients, Number of wards, Bed capacity, Number of QIT members, education of surgeons in the facility, Surgeon of the experience in years, Facility place of residency, Facility Ownership, Distance of PHF from the referral hospital, Level of IPC compliance score and Use of WHO safety check list. The other questionnaire was for QIT members which captured the Age, Sex, Education Level, Cadre/Profession and experience in years. We also had guiding question tool used to gather information for qualitative study.

## Main Comparative Outcome

### Level of Compliance of IPC Measures by PHFs

The outcome was established by determining the level of compliance of IPC by PHFs. Compliance with IPC was established by using IPCAF at the facility level. Change in scores among each core component of IPC based on WHO categories. There were 8 IPC components namely; Core component 1: IPC programmes, Core component 2: National and facility level IPC guidelines, Core component 3: IPC education and training, Core component 4: HAIs surveillance, Core component 5: Multimodal strategies for implementing IPC activities, Core component 6: Monitoring/audit of IPC practices and feedback and control activities, Core component 7: Workload, staffing and bed occupancy at the facility level, Core component, 8: Built Environment, materials and equipment for IPC at the facility level. Cut points followed the recommendation of WHO as 0-200 Inadequate, 201-400 Basic, 401- 600 Intermediate, 601-800 Advanced [16].

### Burden of SSIs in PHFs in Intervention Facilities vs Control Facilities

The checklist for the extraction of cases from the registers was used. That extraction form consisted of question that answered the number of all those who underwent surgery in the specified months in the time of data collection. For a positive response of each question coded as 1 and for negative response of each item gave 2. In this study the cut-off point was 5%. According to estimates by the WHO, the incidence of SSIs in HICs ranges from 1.2 to 5.2%, while that in LMICs is 10.8%. [17]. In this study we will use cut off point of 5%. The SSIs were also be categorized as superficial, deep and space/organ [18]. For our study the outcome was dichotomized as superficial versus deep/organ.

## Sampling Technique

This study intended to use primary level of the health care provision (PHFS). Multistage cluster sampling procedure was used to select representative facilities from eight zones of Tanzania. The country had eight known admirative zones. The inclusion of these zones in the country was due to the geography and size of the country. However, the standard of healthcare provision was more or less homogeneous across the zones. Also, the health system of Tanzania had been divided into primary, secondary and tertiary levels of healthcare as described in item.

The eight administrative zones involved in sampling were: 1. central zone with 3 regions (Dodoma, Singida and Manyara), 2. Special Dar es Salaam Zone with 3 health sub-regions (Ilala, Temeke and Kinondoni), 3. Eastern zone with two regions (Morogoro and Pwani), 4. Lake zone which had six regions (Geita, Kagera, Mara, Mwanza, Shinyanga, and Simiyu), 5. Northen zone which had three regions (Arusha, Kilimanjaro, and Tanga), 6. Southen zone had three zones (Lindi, Mtwara and Ruvuma), 7. Southern highlands zones which had two regions (Iringa and Njombe), 8. South West highlands with two regions (Mbeya and Songwe) and 9. Western zone which had three regions (Rukwa, Katavi, Tabora and kigoma).

The first sampling stage involved creating two sampling frames of zones. The first zonal sampling frame included zones with regions conducting syndromic surveillance while the second zonal sampling frame involved other zones with region not participating in syndromic surveillance. In each zone one region was picked while in lake zone two regions were picked that is overall 10 regions out of 26 regions were sampled whereas 5 regions were for those conducting syndromic surveillance and 5 regions those did not conduct syndromic surveillance using simple random procedure. The simple random sampling was done by rotary method to pick regions names

from each zone one by one.

The second sampling stage involved PHFs selection in the chosen regions selected. Two primary level health facilities sampling frames was created using district hospitals in which district hospitals within 50 km and the other one health facilities located more than 50 km in each sampled region in each zone one by one. One district hospital was randomly selected from each participating region using rotary method. The frame from sampled regions doing syndromic surveillance and regions not doing syndromic surveillance were used to randomly select facilities using rotary method. Hence in total there were 20 primary health facilities two per each region.

Third sampling stage used non-probabilistic sampling method to purposefully select individuals who will participate in the study from each selected health facility in the participating region. All patients who had undergone surgery in the September, October and November of the time of data collection were included in the study. Likewise, the same process was done for the regions that had not started to report syndromic surveillance as control groups which were used as control group. Also, QIT members were selected purposefully by including those who were available and consented during data collection days to be involved in IPC assessment using IPCAT WHO tool.

## Sample Size Estimation

Estimation of sample size for surgical patients was based on two-sample comparison of proportions of SSIs in the facilities which conducted syndromic surveillance and PHFs that did not conduct syndromic surveillance as the control group. From previous studies, the prevalence of SSIs in the facilities that conducted syndromic surveillance was found to be (P1)6.6% (King et al., 2014) and Prevalence of SSIs in the facilities that do not conducts syndromic surveillance is (P2) was 10.9 [19] The formula which we are used for the sample size n, was according to [20]:

$$n = \frac{[Z\alpha/2 * (2p(1-p) + Z1 - \beta(P1(1-P1)\ P2(1-P2)]^2}{(P1-P2)^2}$$

where Zα/2 was the critical value of the Normal distribution at α/2 for a confidence level of 95%, α was 0.05 and the critical value was 1.96. The confidence level was 95%, then this means we had a 5% probability of incorrectly detecting a significant difference when one does not exist, i.e., a false positive result (type I error).

Zβ was the critical value of the Normal distribution at β for a power of 80%, β was 0.2 and the critical value was 0.84 and p1 and p2 were the expected proportions of the two groups events of interest (Outcome), p was (P1-P2)/2. The power is the probability of detecting a significant difference when one exists. If the power is 80%, then this means we have a 20% probability of failing to detect a significant difference when one does exist, i.e., a false negative result (type II error).

Hence, replacing the values in the above formula:

$$n = \frac{[1.96*(2*0.0215(1-0.0215)+0.84(0.109(1-0.109)*0.066(1-0.66)]^2}{(0.109066)^2}$$

$$n = \frac{[1.96 * 0.2051 + 0.84 * 0.2942]^2}{(0.043)^2}$$

$$n = \frac{[0.4020 + 0.0504]^2}{(0.043)^2}$$

$$n = \frac{0.4524}{0.0019}$$

n = 245 in each group to make it a total of 490 to meet the power of the study requirement, however we shall add 20% in each group to make it 300 per group for correction of unforeseen issues like missing data, etc., however, this study recruited all patients who undergone major surgeries in three months in all twenty (20) sampled PHFs and recruited an average of 75 patients per PHFs. The PHFs (District hospitals) conducts an average of 50 surgeries per month for both major and minor surgeries. Hence, about 1500 participants were recruited. The 49 HCWs were purposefully

sampled from the QITs members who were available at PHFs during data collection.

## Data Management and Analysis

In quantitative part, the data were checked daily for completeness, cleared, edited, coded and double entered in spread excel sheet and then exported to Stata SE version 18 for analysis. Backup of the data was done. Filled questionnaires was stored in a safe place. Measure of Centre tendencies namely Median, range and standard deviation were calculated for continuous variable age. Histogram was also used to display the data. Frequencies and percentages were calculated for categorical variables. The prevalence of SSIs was obtained by computing percentage of SSIs among the intervention and control groups. A comparative analysis to determine difference between the average SSIs burden in PHFs conducting surveillance (exposure group) and those which do not conduct (Control group) was done. The difference of average SSIs burden was compared using independent paired t test. P value and Confidence intervals (95% CI) were reported. Similarly, comparative analysis was done to determine difference between the average Level of compliance of IPC measures by PHFs. The difference of average Level of compliance of IPC measures by PHFs was compared between the group with intervention versus the control group using independent unpaired t test. P value and Confidence intervals (95% CI). Furthermore, the same was repeated for other variables.

In qualitative part, the interviews were transcribed verbatim on the same day of the interview to prevent the loss of information. Transcripts were reviewed by another person to decrease bias and increase interpretive credibility. NVivo version 20.2 (NVivo.exe) was used to derive in vivo codes organized and analyze text and audio data through the process of qualitative coding using a hybrid approach for both deductive and inductive. The codes were used to develop categories, which eventually were used to come up with thematic content, which derived the subthemes and themes. The findings were reported by using consolidated criteria for reporting qualitative research [36]. The result of qualitative was used to triangulate the quantitative results. The recorder for the qualitative data was well stored.

# Results

## Univariate Analysis

### Description of the Study Participants

The data collection was conducted between February and May 2025 at in the selected PHFs of Tanzania. A total of 20 PHFs were sampled and 1505 patients who underwent surgery between September and November 2024 were recruited into the study in order to assess for effect of Syndromic Surveillance of SSIs on infection prevention improvement in PHFs. The semi structured questionnaires were used to collect the information. Of the 1505 surgical patients recruited 124 (8.2%) had SSIs and out of them 37 (04.09) came from the intervention group and 87 (14.5%). This means an estimate of nine [9] people out of hundred gets SSIs when undergo surgery in PHFs of Tanzania.

In the KII, it was reported that the syndromic surveillance is essential in determining the burden or prevalence, as well as the incidence of the SSIs. The primary purpose of SSI surveillance in the aspect of IPC is tracking and reporting infections that arise following surgery. Also, it is used to obtain knowledge on the source of infection in patients who undergo surgery. *One of the respondents said "... SSI surveillance is used in determining the magnitude of SSI cases and assessing the results of SSI prevention initiatives" (AM-1 Nurse practitioner).* Some other participants said "….. *SSI surveillance is used as a crucial component of safe surgery practices since it helps track and reduce the incidence and prevalence of SSIs and enhances patient outcomes, particularly to risk patients like children and the elderly*" (JM -2 Nurse Officer,

SDM-1 Medical practitioner).

By tracking SSI rates, hospitals can identify areas for improvement, plan to rectify the problems, implement targeted treatments, and assess the effectiveness of their IPC strategies. Some respondents reported "…. *SSI surveillance is mostly used for determining the etiology in terms of cause and source of infections, as well as the number of those who get infected*" (JM-3 Nurse practitioner, SB-1 Lab technician). One of the respondents thought that….. "*Another usefulness of SSI surveillance is on the data that presents an alarming picture of the incidence of rates of SSI, highlighting the necessity of heightened awareness, prevention initiatives, and continuing with strong surveillance systems to lessen the impact of these SSI on our surgical patients*…" (SDM-1 Medical practitioner).

## A Description of the Participants' Demographics between Study Groups

The sample consisted of two groups namely the one with intervention (n=905) and the control group (n=600). Table 1 below shows the distribution of the participants to either the control group or the intervention group. Majority of the participants were from the facilities with the intervention. Also, there were more female participants 53 (05.9) in intervention group and males in control group 72 (12.0). In extreme age groups the majority were in the control group while that of (20–34) were majority of the participants 673 (74.4%) were in the intervention side, 673 (74.4) in the intervention group while the males where 340(56.7) in control group. Also, occurrences of SSIs were more in control group 87 (14.5) Furthermore, many participants were from rural health facilities 551 (60.9). Majority of other demographic characteristic were more in the intervention group than in the control group as depicted in Table 1.

**Table 1.** Table showing Description of the Participants' Demographics between Study Groups

| **Participants' Characteristics** | **Study Groups** | | **Total** |
|---|---|---|---|
| **Variables** | **Intervention Group (N=905) n (%)** | **Control Group (N=600) n (%)** | **Total (N=1505) n (%)** |
| **Sex** | | | |
| Male | 53 (05.9) | 72 (12.0) | 125 |
| Female | 852 (94.1) | 528 (88.0) | 1380 |
| **Age** | | | |
| 19 years and below | 94 (10.4) | 115 (19.2) | 209 (13.9) |
| 20 – 34 | 673 (74.4) | 340 (56.7) | 1013 (67.3) |
| 35+ | 138 (15.2) | 145 (24.1) | 283 (18.8) |
| **Residency** | | | |
| Rural | 551 (60.9) | 323 (53.8) | 874 (58.1) |
| Urban | 354 (39.1) | 277 (46.2) | 631 (41.9) |
| **Distance from referral Hospital** | | | |
| 50 km or more | 375 (41.4) | 309 (51.5) | 839 (55.7) |
| Less than 50km | 530 (58.6) | 291 (48.5) | 666 (44.3) |
| **Ownership** | | | |
| Public | 853 (94.6) | 518 (86.3) | 1317 (91.1) |
| Private | 375 (41.4) | 82 (13.7) | 134 (08.9) |

| | | | |
|---|---|---|---|
| **SSI** | | | |
| Yes | 37 (04.09) | 87 (14.5) | 124 (8.2) |
| No | 868 (95.91) | 513 (85.5) | 1381(91.8) |
| **Type of SSI** | | | |
| Superficial | 06 (16.2) | 14 (16.1) | 20 (16.1) |
| Deep/organ | 31. 83.8) | 73 (83.9) | 104 (83.9) |

## Description of the Characteristics of the Selected Primary Health Facilities

In this study the variables came from both patients and the health facilities where the patients were getting surgical services. In this section we have described the characteristics of the PHFs. The selected PHFs were 20 which had been sampled from across the zones and regions of Tanzania. Out of those selected PHFs 10 (50%) were the facilities which conducts SSI syndromic (intervention site) surveillance while the other half do not (control side). In terms of availability of work force, in these PHFs majority 11 (50%) had less than 50% of the required number according the level and the population they serve. Also, 13 (65%) of them were attending more than 1500 patients in a month. Furthermore, number of wards were above six in 10 (50%) of them and on the other hand, some of them 08 (40%) had bed capacity of more than 150. The team that oversees quality in majority PHFs 11 (55%) had below 15 members. Other details of those facilities are found in Table 2 below.

The KII reported that surveillance of SSIs is used for determining the relationship of risk factors, infection rate patterns, trends and who is affected the most in terms of age, sex, etc., pinpointing regions that need work, and assessing how well IPC measures are working. The respondents reported that *"…. By gathering and evaluating SSI data, HFs can compare, relate, and monitor trends over time, assess their performance against standards, and carry out focused actions to lower infection rates and enhance patient outcomes"* (SDM-2 medical Officer). Another respondent said "……*It assists in comparing, relating and evaluating the success of preventative measures, and directing initiatives to lower the risk of SSIs as well as to make wise decisions and enhance patient outcomes. This information is essential*…." (HVM-1 assistant physiotherapist).

**Table 2.** Description of the Selected Health Facilities (N=20)

| Variable | Total (N=20) | Percent (%) | Confidence interval at 95% |
|---|---|---|---|
| **Availability of healthcare workers as per MoH establishment** | | | |
| 50% and more | 09 | 45.0% | 24.2% - 67.7% |
| Less than 50% | 11 | 55.0% | 32.3% - 75.8% |
| **Average number of patients attended in a Month (OPD&IPD)** | | | |
| 1500 and bellow | 07 | 35.0% | 16.7% - 58.9% |
| More than 1500 | 13 | 65.0% | 41.0% - 83.3% |
| **Number of wards** | | | |
| Six and Bellow | 10 | 50.0% | 28.2% - 71.8% |
| Above six | 10 | 50.0% | 28.2% - 71.8% |
| **Bed capacity** | | | |
| 150 or bellow | 12 | 60.0% | 36.5% - 79.5% |

| | | | |
|---|---|---|---|
| More than 150 | 08 | 40.0% | 20.4% - 63.4% |
| **Number of Quality Improvement Members** | | | |
| 15 and above | 9 | 45.0% | 24.2% - 67.7% |
| Less than 15 | 11 | 55.0% | 32.3% - 75.8% |
| **Education level of the surgeons in the selected PHFs** | | | |
| One degree and bellow | 13 | 65.0% | 41.0% - 83.3% |
| More than one degree | 07 | 35.0% | 16.7% - 58.9% |
| **Level of the surgeon Experience** | | | |
| Five years and above | 04 | 20.0% | 07.2% - 44.6% |
| Less than five years | 16 | 80.0% | 55.4% - 92.8% |
| **Facility Ownership** | | | |
| Public | 18 | 90.0% | 65.4% – 97.7% |
| Rural | 02 | 10.0% | 2.28% – 34.5% |
| **Residency of PHF** | | | |
| Urban | 08 | 40.0% | 20.4% - 63.4% |
| Rural | 12 | 60.0% | 36.5% - 79.5% |
| **Distance of PHF from referral hospital** | | | |
| More than 50km | 14 | 70.0% | 45.6% - 86.6% |
| 50km or bellow | 06 | 30.0% | 13.3% - 54.3% |
| **Level of IPC Compliance** | | | |
| Inadequate/Basic | 13 | 65.0% | 41.0% - 83.3% |
| Intermediate/Advanced | 07 | 35.0% | 16.7% - 58.9% |
| **Use of WHO Safe Surgery Checklist** | | | |
| Yes | 13 | 65.0% | 41.0% - 83.2% |
| No | 07 | 35.0% | 16.8% - 59.9% |

## Description of the Selected Health Facilities between Groups

In this table 3 below, comparison between PHFs has been done based on either they belong to intervention or control group. It was identified that majority of the PHFs in the control group 6 (60%) had less than 50% healthcare workers while the PHFs in the intervention group had only in 5 (50%) PHFs. Meanwhile, in the control group 8 (80) attended more than 1500 patients while in the intervention on in 5 (50%) attend more than 1500 patients in the month. Also, the control group had PHFs 7 (70) with wards more than six while those with intervention group had only 3 (30%) with more than six wards. Furthermore, in control group no health facility had surgeon's experience more than five years while in the intervention group 4 (40%) of PHFs had. The details are shown in the table 3 below.

**Table 3.** Comparison Description of the Selected Health Facilities between Groups (N = 20)

| Variable | Study Groups | | Total |
|---|---|---|---|
| | Intervention Group (N=10) n (%) | Control Group (N=10) n (%) | |
| **Availability of healthcare workers as per MoH establishment** | | | |
| 50% and more | 5 (50) | 4(40) | 9 (45) |
| Less than 50% | 5 (50) | 6 (60) | 11 (55) |
| **Average number of patients attended in a Month (OPD&IPD)** | | | |
| 1500 and bellow | 5 (50) | 2 (20) | 7 (35) |
| More than 1500 | 5 (50) | 8 (80) | 13 (65) |
| **Number of wards** | | | |
| Six and Bellow | 7 (70) | 3 (30) | 10 (50) |
| Above six | 3 (30) | 7 (70) | 10 (50) |
| **Bed capacity** | | | |
| 150 or bellow | 6 (60) | 6 (60) | 12 (60) |
| More than 150 | 4 (40) | 4 (40) | 8 (40) |
| **Number of Quality Improvement Members** | | | |
| 15 and above | 5 (50) | 4 (40) | 9 (45) |
| Less than 15 | 5 (50) | 6 (60) | 11(55) |
| **Education level of the surgeons in the selected PHFs** | | | |
| One degree and bellow | 8 (80) | 5 (50) | 13 (65) |
| More than one degree | 2 (20) | 5 (50) | 7 (35) |
| **Level of the surgeon Experience** | | | |
| Five years and above | 4 (40) | 0 (00) | 4 (20) |
| Less than five years | 6 (60) | 10 (100) | 15 (80) |
| **Facility Ownership** | | | |
| Public | 9 (90) | 9 (90) | 18 (90) |
| Rural | 1 (10) | 1 (10) | 02 (10) |
| **Residency of PHF** | | | |
| Urban | 3 (30) | 5 (50) | 08 (40) |
| Rural | 7 (70) | 5 (50) | 12 (60) |
| **Distance of PHF from referral hospital** | | | |
| More than 50km | 7 (70) | 7 (70) | 14 (70) |
| 50km or bellow | 3 (30) | 3 (30) | 06 (30) |
| **Level of IPC Compliance** | | | |
| Inadequate/Basic | 4 (40) | 9 (90) | 13 (65) |
| Intermediate/Advanced | 6 (60) | 1 (10) | 07 (35) |
| **Use of WHO Safe Surgery Checklist** | | | |
| Yes | 7 (70) | 6 (60) | 13 (65) |
| | 3 (30) | 4 (40) | 07 (35) |

## The Mean Difference between the PHFs that Conduct SSI Surveillance Versus Those Which don't Conduct

The analysis to evaluate different variables to understand the differences between the study groups was conducted. Many variables were

not different as seen in the table 4 and hence justifying to be the sister groups for the intervention and the control. The comparison between two groups in terms of IPC adherence score showed there was difference between the groups. The group where syndromic surveillance is being conducted had higher mean score of 400.1 SD 138.99 than the control group had mean score of 263.1 SD 99.8. There was statistically significant difference between those two groups 137 SE 54.12; CI = 32.3–250.7 and unpaired t = 2.531; p > 0.011. Other variables which had statistically significant difference were two, namely: burden of SSI (high in control group) and number wards in the facility (were more wards in control group). The detail for other parameters has been displayed in Table **4**.

**Table 4.** Mean Difference between Study Groups' Variables

| **Variable** | **Study Groups** | | **Unpaired t** | **Mean Difference (SE)** | **P value Ha: diff > 0** | **95 CI of the Mean Difference** |
|---|---|---|---|---|---|---|
| | **Intervention Group (N=10) n (%)** | **Control Group (N=10) n (%)** | | | | |
| **Score Level of IPC Compliance** | | | | | | |
| Inadequate/Basic | 4 (40) | 9 (90) | | | | |
| Intermediate/Advanced | 6 (60) | 1 (10) | | | | |
| Mean (SD) | 400.1 (138.99) | 263.1 (99.8) | 2.531 | 137 (54.12) | 0.011 | 23.3–250.7 |
| **Number of SSIs** | | | | | | |
| Superficial | 06 (16.2) | 14 (16.1) | | | | |
| Deep/organ | 31. 83.8) | 73 (83.9) | | | | |
| Mean (SD) | 3.7 (2.5) | 8.7 (7.9) | 1.902 | 5.0 (2.6) | 0.037 | −0.5–10.5 |
| **Average number of patients attended in a Month (OPD&IPD)** | | | | | | |
| 1500 and bellow | 5 (50) | 2 (20) | | | | |
| More than 1500 | 5 (50) | 8 (80) | | | | |
| Mean (SD) | 22658.3 (4.6*104) | 4848.9 (5.5*103) | 1.229 | 17809.4(1.4*104) | 0.235 | −12641.65–48260.45 |
| **Number of wards** | | | | | | |
| Six and Bellow | 7 (70) | 3 (30) | | | | |
| Above six | 3 (30) | 7 (70) | | | | |
| Mean (SD) | 5.5 | 7.7 | 1.917 | 2.2 (1.1) | 0.037 | −0.2–4.6 |
| **Bed capacity** | | | | | | |
| 150 or bellow | 6 (60) | 6 (60) | | | | |
| More than 150 | 4 (40) | 4 (40) | | | | |
| Mean (SD) | 126.4 | 153.4 | 0.915 | 27 (29.5) | 0.372 | −35.0–89.0 |
| **Number of Quality Improvement Members** | | | | | | |
| 15 and above | 5 (50) | 4 (40) | | | | |
| Less than 15 | 5 (50) | 6 (60) | | | | |
| Mean (SD) | 14.1 | 15.3 | 0.489 | 1.2 (2.4) | 0.630 | −3.9–6.4 |
| **Availability of healthcare workers as per MoH establishment** | | | | | | |
| 50% and more | 5 (50) | 4 (40) | | | | |
| Less than 50% | 5 (50) | 6 (60) | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Mean (SD) | 57.8 (28.4) | 46.7 (19.43) | 1.0197 | | 0.3214 | −11.77–33.97 |

It was reported by KII that the health facilities that conduct SSI surveillance were more likely to reduce the chances of SSIs happening than those that don't. The main usefulness of syndromic SSI surveillance is detecting and treating the organisms immediately, since it can serve as an early warning system for possible outbreaks, consequently mitigating the burden compared with those who do not conduct surveillance. One participant reported "…. *Surveillance is useful because instead of putting broad, sometimes ineffectual measures into place, healthcare facilities may concentrate their resources and efforts on the areas that most require improvement and hence intensifying adherence to IPC and improve more and more*…." (SM-1 Medical officer). Some other participants said *"…. SSI surveillance's usefulness is in prioritizing hospital cleanliness, especially in the operating room and wards. That is what one of the participants emphasized*…." (ADE- 21 Nurse Practitioner). *With an emphasis on keeping the hospital environment clean, successful SSI surveillance necessitates monitoring infections, determining risk factors, and assessing the success of preventative actions another respondent reported*…" (KGH-22 Nurse Practitioner).

## Discussion

### The Effect of Syndromic Surveillance on IPC Compliance

Syndromic surveillance for SSIs can positively impact healthcare worker (HCW) compliance with IPC measures in PHFs. When HCWs see the impact of their practices on infection rates, they may be more motivated to adhere to IPC guidelines, leading to better compliance. The surveillance data can inform targeted training programs for HCWs, addressing specific areas where knowledge gaps or compliance issues exist. This study has found the PHFs that conduct syndromic surveillance have high score of HCWs to comply with IPC principles with mean (SD) difference of 137 (54.12); $p > 0.011$ compared to those which do not conduct. These results are matching with the results reported around the world. Based on systematic reviews, meta-analyses, and GRADE approaches, the WHO and CDC have created and released SSI prevention guidelines [21-23]. These were the first significant SSI guidelines to shift from advice based on expert opinion to supported by research. These culturally evidence-based healthcare intervention strategies offer the best possibility for an IPC program to be implemented successfully. This is also well-matched with the study that elaborated the IPC core component four on HAI surveillance. (10). It states that Surveillance systems are generally well-known for their ability to assess the local burden of HAIs and for their role in early detection of HAIs, including bundle and outbreak identification.

Based on the local HAIs condition and adherence to IPC procedures, IPC activities ought to address the healthcare facility's realistic needs. For these reasons, both national and facility IPC programs must include surveillance systems for HAIs. Also, Puro V, et al in 2022 documented that Surveillance of HAIs is critical to inform and guide IPC strategies [24]. Furthermore, A fundamental component of IPC is infection surveillance which assists ongoing quality improvement, process metrics and clinical outcomes, such HAI detection, measure of its magnitude [25]. By providing timely data on infection rates, syndromic surveillance can highlight areas where IPC practices may be lacking, prompting targeted interventions and education to improve HCW compliance. Syndromic surveillance systems, especially those focused on SSIs, can quickly identify potential outbreaks or clusters

of infections. The data from syndromic surveillance can pinpoint specific IPC practices that need improvement, such as hand hygiene, proper wound care, or use of personal protective equipment (PPE).

In addition to syndromic surveillance this study had evaluated other factors between PHFs in intervention and control groups. One of the factors is number of patients attended in the health facilities and how it impacts the adherence of IPC to HCWs. It is the fact that HCWs' compliance with IPC procedures can be adversely affected by overcrowding in healthcare facilities. This is because overcrowding makes it difficult to maintain appropriate patient separation, physical distance, and availability to essential services like handwashing stations, PPE. Overcrowding in health care facilities is recognized as being a public health issue that is associated with disease transmission. A combination of factors was considered when determining the patient-to-bed ratio and the health care worker-to-patient ratio, including number of beds, number of wards, and the availability of a trained workforce. These factors may interfere with providing optimal staff-to-patient ratio, which could potentially lead to increased rates of HAI and the spread of AMR [10]. However, our study has found the managing patient less or more than 1500, bed capacity of less or more than 150 at PHFs had no difference between PHFs. The difference in the IPC score could be explained by the SSI syndromic surveillance conducted by the intervention group.

On the other side, the number of wards in a healthcare facility significantly impacts IPC adherence, with larger facilities facing greater challenges in maintaining consistent practices. This is due to increased workload, potential overcrowding, and logistical hurdles in ensuring adequate resources and training across all areas. Larger facilities with more wards have a more complex infrastructure, making it harder to manage resources, maintain consistent protocols, and ensure all staff are adequately trained and equipped. Larger facilities often experience higher patient volume, potentially leading to overcrowding in wards. This can strain resources, increase the risk of cross-contamination, and make it more difficult for staff to adhere to IPC guidelines. Increased patient volume and the complexity of larger facilities can lead to increased workload and staff burnout, potentially impacting the quality of care and IPC practices. Distributing resources like PPE, hand hygiene supplies, and cleaning materials effectively across multiple wards can be challenging. Ensuring that all staff in all wards receive consistent and adequate IPC training and that adherence to protocols is regularly supervised, becomes more difficult in larger facilities. This study is in keeping with the above facts. Majority of facilities in the intervention group had six or a smaller number of wards in their PHFs and was statistically different with the control group.

Implementation of syndromic activities and IPC interventions need to be overseen by experts and managers. IPC at the facility level receives support from the highest-level public health authorities with a planned and effective national IPC structure [16]. Having a robust structure and capacity in IPC at national and local levels strengthens the ability to plan and implement IPC and respond to communicable disease emergencies [16]. This is reflected in the World Health Organization's (WHO) Core Components of IPC [16], in which the first six components have requirements at the national and facility levels. In Tanzania QIT through IPC committee in the facilities is responsible for that obligation. They significantly impact IPC adherence by implementing evidence-based strategies, monitoring performance, and fostering a culture of safety. This collaborative approach, often integrated into quality assurance programs, helps reduce HAIs and improve overall patient safety. QITs work to create and update IPC policies and procedures based on the latest scientific evidence and best practices. These policies should be clearly

communicated to all staff and stakeholders. QITs track and analyze infection rates, identify areas of concern, and assess the effectiveness of implemented interventions. This data-driven approach helps pinpoint areas needing improvement and tracks progress over time. QITs play a vital role in educating healthcare workers on proper IPC practices, including hand hygiene, proper use of PPE, and sterilization techniques. A QIT ensures that healthcare facilities have the necessary resources and equipment to implement IPC practices effectively. QITs promote a culture of safety where staff feel empowered to report errors, participate in improvement initiatives, and prioritize patient safety. By integrating IPC activities into broader quality assurance programs, QITs ensure that IPC is not a separate initiative but rather a core component of the overall quality of care. Contrary to the findings of this study, the intervention group and the control group were not different in terms of number of QIT members. The difference in IPC score could be attributed to the syndromic surveillance conducted by the intervention group.

Syndromic surveillance data can be used to identify specific areas or procedures where SSIs are most common. This allows for the development of targeted interventions, such as tailored training programs or the implementation of specific preventative measures, to address these areas. Overall, syndromic surveillance plays a crucial role in improving IPC compliance by providing a framework for early detection, data-driven improvement, increased awareness, accountability, and targeted interventions. Effective syndromic surveillance requires well-trained staff to identify, document, and report cases, as well as to interpret the data and implement appropriate interventions. Adequate resources, including staff time, training materials, and appropriate infrastructure, are essential for successful implementation. Effective surveillance relies on strong collaboration between different departments within the healthcare facility, as well as with public health agencies. In essence, syndromic surveillance provides a feedback loop, helping to identify areas where IPC practices need improvement and motivating HCWs to enhance their compliance, ultimately leading to a safer environment for patients. By improving HCW compliance with IPC measures, syndromic surveillance can ultimately contribute to a reduction in SSI rates, improving patient outcomes. For example, if syndromic surveillance data shows a spike in SSIs following a particular type of surgery, it might trigger an investigation into the surgical technique, instrument sterilization, or hand hygiene practices of the involved HCWs. This could lead to targeted training on proper surgical technique, increased emphasis on hand hygiene before and after the procedure, or changes in the sterilization process.

## The Effect of Syndromic Surveillance on Burden of SSI

HAI detection is key in planning the IPC measures. The detection will provide the magnitude which will eventually provide the clear picture of the interventions in place and the need to adjust. This study has shown that, the health facilities which conduct syndromic surveillance have the potential of having reduced number of SSIs compared with the facilities that do not conduct the syndromic surveillance with mean (SD) of 5.0 (2.6); $p > 0.037$. This is marching with the systemic review done in Africa which showed the prevalence of HAIs is higher than in the developed world where HAIs surveillance is being done [26]. Also, according to the large, international cohort study, pooled SSI rates were associated with a stable and sustainable decrease after joining an SSI surveillance network; a causal relationship is possible, although unproven. There was heterogeneity in procedure-specific trends. These findings support the pivotal role of surveillance in

reducing infection rates and call for widespread implementation of hospital-based SSI surveillance in high-income countries [27].

Syndromic surveillance can significantly impact the burden of SSIs by enabling early detection and response, potentially leading to reduced infection rates and improved patient outcomes. By monitoring trends in symptoms rather than waiting for confirmed cases, syndromic surveillance can trigger timely interventions to prevent further spread and mitigate the impact of SSIs. Furthermore, the use of SSI surveillance which have been stipulated in several papers has shown use of surveillance has helped in reduction of SSI burden [28-32]. The basis for hospital-level initiatives aimed at SSI reduction is provided by these suggestions and related implementation strategies. The best way to introduce important structural changes, procedural modifications, and behavioral skills for all healthcare staff is to establish IPC programs with SSI surveillance components. One of the strategies to mitigate HAIs is using the teams from throughout the health system that are in charge of surgical patient care in the identification of SSIs, which may be less challenging than other HAIs. SSIs may be addressed by the surgeon and a range of other healthcare providers. Surveillance is crucial to reducing SSI rates, and to achieve this, a trained team is necessary to examine at-risk wounds and support the dissemination of results.

Syndromic surveillance gives early warning system that allow for faster identification of potential outbreaks or clusters of SSIs, enabling healthcare facilities to implement targeted interventions sooner [33]. By detecting potential SSIs early, syndromic surveillance facilitates prompt implementation of infection control measures, such as enhanced hand hygiene protocols, antibiotic stewardship, and isolation procedures [34, 37]. This proactive approach can prevent the spread of infection to other patients and healthcare workers, reducing the overall burden of SSIs. Early detection and intervention associated with syndromic surveillance can lead to reduced severity and duration of SSIs [35]. This can result in fewer complications, shorter hospital stays, and decreased mortality rates related to SSIs. Syndromic surveillance can help optimize the allocation of resources by focusing on areas with higher rates of infection. By identifying trends and hotspots, resources can be directed towards specific surgical procedures, departments, or patient populations at higher risk for SSIs.

The overall effect of syndromic surveillance is an improvement in patient safety by minimizing the risk of SSI development and its associated complications. This can lead to greater patient satisfaction and trust in healthcare services. By reducing the incidence and severity of SSIs, syndromic surveillance can contribute to lower healthcare costs associated with prolonged hospital stays, additional treatments, and potential legal liabilities. Syndromic surveillance can be integrated with existing surveillance systems, such as interpreted Disease Surveillance and Response (IDSR) and DHIS2, to enhance data collection and analysis. This integration can provide a more comprehensive picture of SSI burden and facilitate more effective interventions. Syndromic surveillance plays a crucial role in mitigating the burden of SSIs by facilitating early detection, enabling timely interventions, and ultimately contributing to improved patient outcomes and resource optimization.

## Conclusion

Syndromic surveillance of SSI plays important role in improving IPC in the PHFs through provision of data that is being used by HCWs to develop interventions to mitigate or eradicate SSI from the surgical patients. Although the effects are less remarkable, syndromic surveillance may be associated with improvement of IPC that in turn reduce the burden of SSI. Less SSI has been observed in

PHFs that conduct syndromic surveillance compared to those which do not. Further well-designed studies involving larger samples involving may countries and a follow up study may help to reliably quantify the risks of SSI and inform professional guidelines to help PHFs provide evidence-based advice on SSI.

## Conflict of Interest

There was no conflict of interest among the authors.

## Data Availability

The corresponding author can provide the data that is supporting the study's conclusions upon request at any time.

## Author Contributions

**JCH:** Conceptualization, Methodology, Writing of Original Draft, Funding Acquisition data collection, analysis and report writing.

**BFS:** Supervision, editing of both proposal and the report.

**AC:** Supervision, editing of both proposal and the report.

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## Ethics Statement

The research plan was approved by the Tanzanian Ministry of Health (reference number PA 131/142/01/412) and the President's' Office - Regional Administrative and Local Government (reference number AH. 161/323/01/50). Also, the National Institutional for Medical Research granted ethical clearance (reference number NIMR/HQ/R.8a/Vol. IX/4687). In addition, study identification numbers were used instead of using the participants' names to maintain their anonymity. The gathered data were safely preserved on a password-protected computer and in physical copy in a lockable drawer.

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# Multifaceted Interventions and HIV Risky Sexual Behaviours among Adolescent Girls and Young Women: A Case Study of the DREAMS Partnership in Mubende Region, Uganda

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***Abstract*** *Risky sexual behaviour among Adolescent Girls and Young Women (AGYW) is a global health challenge resulting in new cases of HIV infection, sexually transmitted Infections (STIs), unwanted pregnancies and unsafe abortions. This study aimed at examining the effectiveness of multifaceted interventions on reduction of risky sexual behaviours (RSBs) among AGYW in Mubende region, Uganda. The study adopted a descriptive cross-sectional design for both qualitative and quantitative data collection and analysis. Quantitative data was gathered through pre-tested structured questionnaires from 385 randomly selected participants, while qualitative data was collected via focus group discussions and key Informant interviews with purposively selected respondents. Quantitative data was analyzed using STATA 18.0 software, while qualitative data was transcribed verbatim and analyzed using NVIVO software. The findings revealed that 92.5% of the target population was reached by DREAMS interventions. Marital status (AOR = 0.17, 95% CI: 0.04–0.64, p = 0.01), Education status (AOR = 0.001,95% CI: 0.00-0.00, p<0.001 ), Age at enrollment (AOR = 49.52,95% CI:1.24-1981.93, p= 0.038), Journeys plus (AOR=22.75, 95% CI: 1.26-409.98, p= 0.034), employment after graduation (AOR=14.57, 95% CI: 1.15-184.00, p=0.038), marriage after graduation (AOR=15.95, 95% CI: 1.11-229.21, p=0.042) and starting own business after graduation (AOR=15.32, 95% CI: 1.66-141.33, p=0.016), were the independent variables significantly associated with RSBs. HIV prevention and sexual health, economic empowerment, behaviour change, employment opportunity, reduced unintended pregnancies, retention in school and asset building were identified as the major outcomes achieved by the program. Education status, Marital status, age enrollment, Journeys plus curriculum, employment, marriage and starting own business after graduation positively influenced RSBs.*

***Keywords*** *Adolescent Girls and Young Women, DREAMS, Multifaceted, Risky Sexual Behaviours.*

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## Introduction

Risky sexual behaviour (RSB) among adolescent girls and young women (AGYW) is a global health challenge resulting into new cases of HIV infections, sexually transmitted diseases (STDs), unwanted pregnancies and unsafe abortions. Risky sexual behaviours (RSBs) are defined as sexual activities that predispose an individual to the risk of acquiring sexually transmitted infections including HIV and unplanned pregnancies [1, 2]. The major risky sexual behaviours among AGYW include, early sexual debut, age-disparate sex, multiple partnerships, incorrect and inconsistent condom use, transactional sex, drinking alcohol and substance abuse, gaps in knowledge and limited personalized risk perception. Adolescence is a period of life from childhood which involves experimentation and exploration when individuals experience rapid physical, cognitive and social-emotional changes as they transition to adulthood leading them to engage in risky sexual behaviors.

Globally, about one million cases of sexually transmitted diseases are reported daily and adolescents account for approximately 50% of these cases arising from RSBs [3] According to World Health Organization (WHO) global estimates, 376 million new STIs of chlamydia, Gonorrhea, syphilis and Trichomoniasis were reported [3]. This has led to high rates of Sexually Transmitted Infections (STIs) in adolescents compared to other age groups with over 30% of new HIV infections and majority of STDs occurring in this population each year. Worldwide, AGYW aged (15-24 years) are disproportionately affected with HIV infection as compared to their male counterparts due to their increased level of vulnerability [4, 5]. Lack of appropriate interventions to protect the AGYW and cater for their sexual and reproductive health needs results in disproportionately high HIV prevalence globally among this target population. Approximately, 1.9 million AGYW aged (15-24 years) were living with HIV globally as compared with 1.2 million adolescent boys and young men in the same age band [5].

In Sub-Saharan Africa (SSA), the incidence of HIV was estimated at 210,000 among AGYW (15-24 years) in 2022., Women and girls (all ages) accounted for 63% of all new HIV infections. Eighty-two per cent of AGYW who acquired HIV in 2022 live in Sub-Saharan Africa, including two thirds in eastern and southern Africa. Over 50% of new HIV infections in 2022 occurred among men and boys of the same age in all other geographical regions [6]. Additionally, according to the study in Nigeria to investigate the prevalence of risky sexual behaviors (RSBs) among adolescent girls and young women, evidence revealed that 41.1% and 28.3% of adolescent girls and young women are involved in RSBs, respectively.[7].

It has been proven empirically that sexual behaviours in relation to poverty, gender inequality, gender-based violence, lack of access to education, health care services, social protection and information on HIV prevention are major structural drivers that increase the level of AGWs vulnerability to acquisition of new HIV infection [8, 9]**.** These have led AGYW to be less likely to negotiate for safer sex and engage in risky sexual behaviors that predispose them to HIV infection. In the previous cross-sectional study in Uganda to assess the risky sexual behaviors and HIV and syphilis prevalence among in and out of school AGYW, the findings revealed that 54.5% AGYW had ever had sex, of these 12.9% had their sexual debut before age 15; 19.1% reported a history of STIs. Of those that had ever had sex, 79.6% had sex in the 12 months preceding the survey; 75.6% with one (1) and 24.2% with 2+ partners. Condom use with the most recent sexual partner was low, with only 20.4% reporting consistent condom use while 79.6% reported inconsistent or no condom use [10].

Risky sexual behaviours contributing to increased vulnerability to acquisition of HIV infections among AGYW must be addressed in

a bid to achieve eradication of the HIV/AIDS scourge. To address RSBs as a global challenge among AGYW, achieve HIV Epidemic control and promote AGYW wellbeing, an ambitious public-private partnership called "Determined, Resilient, Empowered, AIDS-Free, Mentored and Safe (DREAMS) was launched on World AIDS Day in 2014. DREAMS project is currently implemented in 15 countries in partnership with donor agencies such as Johnson& Johnson, the Bill and Melinda Gates Foundation, Girl Effect, Gilead Sciences and ViiV Healthcare. DREAMS project was implemented in Fort-Mubende region which is among the DREAMS regions that fulfilled the criterion of high HIV prevalence and incidence according to the burden table [11].

However, despite the heavy investments in DREAMS partnership, evidence on the impact of MIs on reducing risky sexual behaviors among AGYW is not clearly documented and knowledge is still scanty in Uganda which affirms originality of the study. There is no evidence that a similar study using cross-sectional study design to investigate effectiveness of MIs on risky sexual behaviors among AGYW on different cohorts was conducted. This study focused on the DREAMS partnership, a novel, multifaceted program launched in Uganda in 2016, specifically targeting vulnerable AGYW aged 10–24 years. To date, no comprehensive evaluation has been conducted to assess the impact of these interventions on reducing RSBs among this population, making this study the first of its kind in the Ugandan context. Second, the study's novelty is reflected in its specific objectives, which address critical knowledge gaps previously unexplored by other scholars. 1) To assess the Reach of MIs among AGYW and 2) To investigate the influence of MIs on risky sexual behaviors among AGYW.

Multifaceted interventions (MIs) refer to multiple evidence-based approaches provided to AGYW that go beyond biomedical interventions in addressing structure drivers that directly or indirectly increase the girl's HIV risk, DREAMS partnership provides evidence –based interventions (multifaceted interventions) with an aim of reducing risky sexual behaviours among AGYW through service layering with a comprehensive package. The DREAMS theory of change hypothesizes that service layering (when multiple interventions from the core package are delivered to vulnerable AGYW those interventions will act synergistically to change both the program outcomes and impact. DREAMS package is categorized as primary, secondary and contextual services provided according to age band (10-14-year-olds), (15-19-year-olds) and (20-24-year-old) aimed at achieving AGYW_PREV (AGYW prevention), building their human, social, health and economic assets.

Layering of services is a DREAMS fundamental principle based on research from related fields demonstrating that multiple interventions have greater impact on risk behaviors than any single intervention [12]. It is against this backdrop, this study therefore sought to investigate the effectiveness of multifaceted interventions on reduction of risky sexual behaviours among adolescent girls and young women (10-24 years) in Mubende region. Uganda. This study is a scientific contribution to existing knowledge, thereby supporting donors, policymakers, and program implementers in designing evidence-based, efficient and cost-effective strategies to prevent risky sexual behaviours and program replication. Finally, the results of this study can provide useful information for scholars to conduct further research to generate more evidence on this issue.

## Materials and Methods

### Study Design

The study employed descriptive cross-sectional study design using a mixed-methods approach. Data collection was conducted between October and November 2025.

## Study Setting

The study was conducted in Mubende and Mityana districts in Mubende region, Uganda. Mubende region was composed of 4 Sub National Units (SNUs) initially which included Luwero, Mityana, Kassanda and Mubende districts. Mubende district in the central region of Uganda composed of 18 (Eighteen) sub counties and one town council before splitting from Kassanda district. It covers an area of approximately 4,620 square kilometres. The total Population of Mubende District as contained in the 2014 Population and Housing Census was 684,348 with 346,654 males and 337,694 females. Mityana is a district in the central region of Uganda. It covers an area of approximately 1,579.3 square kilometres. The district has 9 sub counties, fifty-nine parishes and 840 villages. The total Population of Mityana District as contained in the 2014 Population and Housing Census was 328,964 with 165,717 males and 163,247 females.

## Sample Size Determination

The Sample size formula for quantitative variable was employed to obtain the minimum sample size using the formula by Cochran (1976) since the population of the vulnerable AGYW (15-24 years) for the district is known to be large [13].

$$n = \frac{z^2 pq}{e^2}$$

Where: n = the sample size, Z= value of area under the normal curve (Standard normal deviation corresponding to the confidence level of 95% for a tailed test = 1.96), p = Estimated proportion of an attribute present in the population to be 50%, q = 1-p and e = Desired level of precision, which is 5% or 0.05.

Using the formula above the minimum sample size was ascertained.

$$n = \frac{1.96 \times 1.96 \times 0.5 \times 0.5}{0.05 \times 0.05}$$

$$n = \frac{0.9604}{0.0025} = 385$$

Based on the population size of the target population in the two study areas, a total of 125 respondents and 260 respondents participated in the study in Mityana and Mubende districts respectively.

## Sampling Techniques

Sampling refers to the statistical method or process of selecting a portion of the population to represent the entire population or process of selecting individual observations from defined study population [14]. A multistage cluster random sampling technique was used to select AGYW aged (15-33) years in Mubende region. Simple random sampling was used to select respondents to participate in the survey to assess the Reach (Proportion of beneficiaries), factors associated with risky sexual behaviors and multifaceted (MIs) among AGYW. Participants for KII interviews and FGDs were purposively and randomly stratified according to age bands to participate in the study respectively to explore their views and experiences.

## Study Variables

The explanatory variables under study were DREAMS interventions such as Curriculum based interventions, Asset building, socio-economic strengthening (short term and long-term trades), Education subsidy, HIV Testing Services (HTS) and SASA methodology. The dependent variables under study were risky sexual behaviours such as Early sexual debut (before age of 18 years), multiple sexual partners, type of sexual partner, Correct and consistent condom use, transactional sex, age-disparity, alcohol and drug abuse. Socio-demographic factors such as place of residence, marital status, religion, education status, pregnancy status, wealth, household size, Occupation, employment status of caregiver were the confounders in the study.

## Data Collection Techniques and Tools

Data collection tools were designed and pre-tested to capture primary data from Surveys,

KIIs and FGDS for both quantitative and qualitative data collections. Quantitative data was gathered through structured questionnaires from 385 randomly selected participants Survey questionnaires were administered by trained research assistants to AGYW who met the eligibility criteria to participate in the study. The questionnaires comprised of variables on socio-demographics, experience on DREAMS, services offered to the AGYW, sexual activity, HIV status and self-efficacy. Qualitative data was collected via FGDs with AGYW beneficiaries and KIIs with purposively selected facilitators, Artisans and key stakeholders to explore their experiences, opinions, and perceptions. Five (5) FGDs using interview guides were conducted with respondents ranging between 8-12 participants. Three (3) FGDs with AGYW stratified according to age category (15-19 years and 20-33 years) and two (2) FGDs with Facilitators, Instructors and Artisans. Nine (9) KIIs with key stake holders were conducted in the two districts. The discussions were audio recorded after seeking consent from respondents until thematic saturation was reached.

## Data Process and Analysis

Descriptive statistics of central tendency (frequencies) and percentages presented in tables were used to explain the socio-demographics of AGYW. The findings were presented using percentages, frequencies and probabilities to predict whether there was a relationship between MIs and RSBs. Chi-square analysis was performed to determine whether there is an association between MIs and change in RSBs as well as the degree of the association if the results are statistically significant.

Logistic regression was used to obtain the odds ratio to determine the effect between the explanatory variables and response variable as the outcome of interest. Chi-square tests were conducted to assess the association between MIs and RSBs, with results considered statistically significant at a p-value of $<0.05$ and a 95% confidence interval (CI). Following chi-squared Test ($X^2$), stratified analysis was performed to establish the relationship between MIs and RSBs while controlling for each confounder in the study such as age, education status, marital status and pregnancy status. The multivariable logistic regression analysis adjusting for all potential confounders identified from the survey was used to evaluate the independent variables associated with reduction in HIV associated behaviors. All collected data was analyzed using STATA software (Version 18) for quantitative analysis. To quantify the influence between MIs and RSBs odds ratios and 95% confidence Interval (CI) were used. Qualitative analysis was conducted to generate more evidence on whether multifaceted interventions influence RSBs among AGYW. Focus group discussions with AGYW (15-33 years) and program implementers were conducted to explore their experiences, opinions, and perceptions on DREAMS program, knowledge on RSBs and impact using semi –structured interview guide.

The stratified groups with AGYW beneficiaries according to age bands and program implementer had participants ranging from 8-12. KII with key stake holders such as community leaders, program officers, social workers and male partners were conducted using semi-structured KII guide. The investigator decided to use Braun and clerk's (2006) thematic analysis framework to analyze qualitative data. The 6 steps of thematic analysis employed included (1) Familiarizing yourself with the data (2) Generating initial codes (3) Generating initial themes (4) Reviewing themes (5) Defining and naming the themes and (6) Generating a report. When participants were asked about their experience on DREAMS program different responses were highlighted and recorded by the investigator and until thematic saturation was achieved. Qualitative data were transcribed verbatim and analyzed using NVIVO software through

content analysis and a hybrid deductive-inductive thematic approach.

## Results

### Descriptive Socio Demographic Characteristics of Study Participants

Table 1 represents data for socio-demographic characteristics of respondents with variations in percentages, frequencies and Reach of DREAMS. Of the 385 respondents randomly selected to participate in the study, more than half 25 (58%) of the participants were in the age group of 18-24 years, followed by 96 (25%) in the age group of 25 years and above. While 15-17 years accounted for the least 64 (17%) participants, those in union, 230 (60%) were the majority, 262 (68.1%) were out of school and largest proportion 353 (91.7%) were not pregnant. Half of the respondents, 195 (50.7%) were unemployed and 121 (31.5%) were in self-employment. Majority 350 (90.9%) of the respondents' care givers were unemployed. Almost all the participants in this current study, 375 (97.4 %) had heard about DREAMS program, half of the participants 188 (50.1%) received information about the program through the word of mouth. Large proportion of the participants 365 (94.8%) were invited to the program and 356 (92.5%) were enrolled on the program. It was observed that 160 (41.6%) were in the cohort of 2022-2023 and almost half, 173 (49.2%) were in the age group of 20-24 years at enrollment, 142 (40.3%) were in the age band of 15-19 years and the least 37 (10.5%) were in the age band of 10-14 years.

**Table 1.** Socio-demographic Characteristics of Respondents

| Variable | Categories | Frequency | Percentages (%) |
|---|---|---|---|
| **A: Socio-demographics** | | | |
| Age group | 15-17 years | 64 | 16.6 |
| | 18-24 years | 225 | 58.4 |
| | 25+ years | 96 | 24.9 |
| Gender | Other | 0 | 0.0 |
| | Female | 385 | 100.0 |
| Marital Status | In union | 230 | 59.7 |
| | Not in union | 155 | 40.3 |
| Education Status | Never_been_in_school | 9 | 2.3 |
| | Out of school | 262 | 68.1 |
| | In school | 62 | 16.1 |
| | Completed School | 52 | 13.5 |
| Pregnancy status | No | 353 | 91.7 |
| | Yes | 22 | 5.7 |
| | Not sure | 10 | 2.6 |
| Employment status | Unemployed | 195 | 50.7 |
| | Part time | 51 | 13.3 |
| | Full time | 18 | 4.7 |
| | Self employed | 121 | 31.4 |
| Employment status of caregiver | Unemployed | 350 | 90.9 |
| | Employed | 35 | 9.1 |
| **B: Reach of DREAMS** | | | |
| Heard of DREAMS | No | 10 | 2.6 |

| | | | |
|---|---|---|---|
| | Yes | 375 | 97.4 |
| How you hear about DREAMS | CBO/NGO | 31 | 8.3 |
| | LC | 39 | 10.4 |
| | VHT | 81 | 21.6 |
| | Word-of-mouth | 188 | 50.1 |
| | Other | 36 | 9.6 |
| Ever been invited to DREAMS | No | 20 | 5.2 |
| | Yes | 365 | 94.8 |
| Ever been enrolled on DREAMS | No | 29 | 7.5 |
| | Yes | 356 | 92.5 |
| Year of Enrollment | No | 33 | 8.6 |
| | 2016-2017 | 12 | 3.1 |
| | 2017-2018 | 8 | 2.1 |
| | 2018-2019 | 12 | 3.1 |
| | 2019-2020 | 3 | 0.8 |
| | 2020-2021 | 12 | 3.1 |
| | 2021-2022 | 35 | 9.1 |
| | 2022-2023 | 160 | 41.6 |
| | 2023-2024 | 110 | 28.6 |
| Age at Enrollment | 10-14years | 37 | 10.5 |
| | 15-19years | 142 | 40.3 |
| | 20-24years | 173 | 49.2 |
| Know your DREAMS IDs | No | 122 | 34.4 |
| | Yes | 233 | 65.6 |

***Source:*** *Field Survey, October -2025*

## Descriptive Statistics for Uptake of DREAMS Interventions

In the current study, table 2 indicates that 84 (21.8%) participants received Journeys plus curriculum and 303 (78.7%) received stepping stones methodology and majority of the respondents, 219 (56.9%) received No Means No- Female Curriculum. In addition, 131 (34%) received SINOVUYO program and large proportion of 300 (77.9%) received community mobilization and norms change (SASA). Furthermore, 320 (83.1%) received Vocational skills training, while 82 (21.3%) received education support as a secondary service. We observed that,344 (89.4%) belonged to groups, while 346 (89.9%) received services in groups for social asset building. Majority, 337 (87.5%) received HTS screening and of those who were screened, 334 (86.8%) received HIV testing. Additionally, it was observed that large proportion of respondents, 328 (85.2%) were not attending school while 57(14.8%) were still in school. It was observed that after graduation from the program, majority, 113 (29.4%) were able to start their own business, 49 (12.7%) got employed, 71 (18.4%) got married, 55 (14.3%) continued schooling, 53 (13.3%) stayed at home and 44 (11.4%) dropped from school. Finally, large proportion, 340 (88.3%) revealed that the program changed their life and 45 (11.7%) their life unchanged.

**Table 2.** Uptake of DREAMS Interventions

| **C: Exposure to DREAMS interventions** | | | |
|---|---|---|---|
| **Variable** | **Category** | **Frequency** | **Percentage** |
| HIV and violence prevention (Journeys Plus) | No | 301 | 78.2 |
| | Yes | 84 | 21.8 |
| Stepping stones | No | 82 | 21.3 |
| | Yes | 303 | 78.7 |
| No means No - AGYW | No | 166 | 43.1 |
| | Yes | 219 | 56.9 |
| SINOVUYO | No | 254 | 66.0 |
| | Yes | 131 | 34.0 |
| SASA | No | 85 | 22.1 |
| | Yes | 300 | 77.9 |
| Apprenticeship | No | 65 | 16.9 |
| | Yes | 320 | 83.1 |
| Education support | No | 303 | 78.7 |
| | Yes | 82 | 21.3 |
| Belonging to a group | No | 41 | 10.7 |
| | Yes | 344 | 89.4 |
| Received DREAMS services in a group | No | 39 | 10.1 |
| | Yes | 346 | 89.9 |
| HTS screening | No | 48 | 12.5 |
| | Yes | 337 | 87.5 |
| HIV Testing | No | 51 | 13.3 |
| | Yes | 334 | 86.8 |
| **SECTION E: Impact** | | | |
| Currently Attending School | No | 328 | 85.2 |
| | Yes | 57 | 14.8 |
| After graduation | Nothing | 53 | 13.8 |
| | I continued with my studies | 55 | 14.3 |
| | I dropped out of school | 44 | 11.4 |
| | I got employed | 49 | 12.7 |
| | I got married | 71 | 18.4 |
| | Started own business | 113 | 29.4 |
| DREAMS changed my life | No | 45 | 11.7 |
| | Yes | 340 | 88.3 |

***Source:*** *Field survey, October 2025*

## Bivariate Logistic Regression Analysis

In this current study, at bivariate analysis level, all socio-demographic characteristics such as age group, marital status, education status, pregnancy status, employment status, and employment status of care givers were identified to be significantly associated with RSBs among AGYW (Table 3). AGYW in the age group of 15-17 years (79.7%) accounted for the largest proportion that practiced safe sexual behaviour, followed by the age group of 18-24 years (13.3%), least (3.1%) were 25 years and above and difference was statistically significant. Similarly, half of the AGYW (50.3%) not in union and 2.6% in union had safe sexual behaviour with a statistically significant difference (p<0.001). In addition, we observed statistically significant difference between AGYW who were in school (93.6%), those out of school (8.8%) and those that had completed school (5.8%) with safe sexual behaviour and Risky sexual behaviour (p<0.001). On the other hand, other socio-demographic variables that were significantly associated with risky sexual behaviours among AGYW included, pregnancy status (p-value=0.003), employment status (p<0.001) and employment status of care givers (p-value=0.002).

Furthermore, heard of DREAMS, how you heard about DREAMS, ever been invited to DREAMS and age at enrolment were independent variables of Reach identified to be significantly associated with risky sexual behaviours among AGYW (Table3). AGYW who did not hear about DREAMS program (50%) and those who heard about the program (21.1%) had safe sexual behaviour (p<0.001) and this was significantly associated with RSBs. AGYW who had safe sexual behaviour, about half of them (43.5%) heard the program through other channels, 25.8% from CBO/NGO, 19.7% by word of mouth, 18.5% from VHTs and 10.3% from LCs (p-value = 0.002). Significant difference was observed between how the AGYW heard about the program and risky sexual behaviour among AGW. In addition, the results revealed that AGYW ever been invited on the program (20.8%) and those who were not invited on the program (40%) had safe sexual behaviours (p-value= 0,043) and the difference was significantly associated with RSBs. Conversely, those that practiced safe sexual behaviour, largest percentage (86.5%) were in the age band of 10-14 years, 25.4% in 15-19 years and 3.5% in 20-24 years at enrollment. There was statistically significant difference between age at enrollment among the groups and risky sexual behaviours (p< 0.001).

Conversely, AGYW who had never been enrolled on the program (21.4%) and 27,6% who had never been enrolled on the program had safe sexual behaviour and there was statistically insignificant difference (p-value = 0.434). The cohort of 2022-2023 constituted the highest proportion (23.7%) of AGYW who had safe sexual behaviour, followed with the cohort of 2023-2024 (23.6%), 30.3% with no year of enrollment and the least with 22.9% was the cohort of 2021-2022 (p-value= 0.133). There was a statistically insignificant difference between year of enrollment and risky sexual behaviour. Finally, AGYW who did not recall their DREAMS ID number and had safe sexual behaviour accounted for the largest proportion (27.1%) compared to those who knew their ID numbers (18.5%) and this was statistically insignificant predictor of risky sexual behaviours (p-value= 0.061).

Regarding exposure to DREAMS interventions, Journeys plus, stepping stones, No Means NO, Apprenticeship, Education status and HIV testing were the MIs found to be significantly associated with risky sexual behaviours. AGYW engaged in safe sexual behaviours, 44.1% received Journeys plus methodology and 15.6% did not, 14.2% received steeping stones methodology and 50% did not,32% received No Means NO curriculum and 8.4% did not (p<0.001). The observed differences between Journeys plus, stepping stones and NMN-Female curriculum were

significantly associated with risky sexual behaviour. In addition, of those that had safe sexual behaviour, 47.7% received apprenticeship and 16.6% did not (p<0.001), 42.7% received education support and 16.2% did not (p<0.001). There was statistically significant difference observed between receiving apprenticeship and education support and RSBs. Similarly, it was observed that AGYW with safe sexual behaviour, 18.9% received HIV testing and 41.2% did not (p<0.001). There was statistically significant difference between HIV testing and risky sexual behaviour.

Conversely, the findings further indicated that among respondents who had safe sexual behaviour, 29.8% received SINOVUYO and 17.7% did not (p-value=0.007), while 20.7% received SASA methodology & 25.9% did not (p-value =0.304). Statistically insignificant difference was observed between SINOVUYO, SASA methodology and RSBs among AGYW. On the other hand, AGYW who had safe sexual behaviour (24.5%) belonged to a group and 24.4% did not (p-value=0.673), 21.7% received DREAMS services in a group and 21,1% did not receive services in a group (p-value= 0.841). There was statistically insignificant difference observed between belonging to a group, receiving services in a group and RSBs. Additionally, AGYW who had safe sexual behaviour, 21.4% received HTS screening and 25% did not receive (p-value=0.568) and difference was insignificantly associated with RSBs.

Furthermore, we observed that attending school and outcome after graduation were significantly associated with RSBs. According to table 3, AGYW who had safe sexual behaviours, 86% were still attending school and 10.7% were not (p<0.001). Similarly, 35.8% stayed at home after graduation from the program, majority (85.5%) continued with studies, 25% dropped out of school, 6.1% got employed, 1.4% got married and 2.7% started own business (p<0.001). Attending school or graduation from the program had differences significantly associated with RSBs. Finally, AGYW, who had safe sexual behaviour, 21.2% revealed that the program had changed their life and 26.7% responded that the program did not change their life (p-value=0.402). There was statistically insignificant difference observed between change in life attributed to DREAMS and risky sexual behaviours.

**Table 3.** Association between Predictor Variables and Risky Sexual Behaviours Among Adolescents Girls and Young Women (AGYW) in Bivariate Analysis, 2025

| **Variable** | **Categories** | **Sexual Behaviour** | | **Chi-square** | **df** | **p-value** |
|---|---|---|---|---|---|---|
| **A: Socio-Demographics** | | **Safer** | **Risky** | | | |
| Age group | 15-17years | 51(79.7 | 13(20.3) | 154.809 | 2 | 0.000 |
| | 18-24years | 30(13.3) | 195(86.7) | | | |
| | 25+years | 3(3.1) | 93(96.9) | | | |
| Gender | Other | | | | | |
| | Female | | | | | |
| Marital Status | In union | 6(2.6) | 224(97.4) | 123.585 | 1 | 0.000 |
| | Not in union | 78(50.3) | 301(49.7) | | | |
| Education Status | Never been in school | 0(0.0) | 9(100.0) | 223.492 | 3 | 0.000 |
| | Out of school | 23(8.8) | 239(91.2) | | | |
| | In school | 58(93.6) | 4(6.4) | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Completed School | 3(5.8) | 49(94.2) | | | |
| Pregnancy status | No | 81(22.9 | 272(77.1) | 6.795 | 2 | 0.003 |
| | Yes | 0(0.0) | 22(100.0) | | | |
| | Not sure | 3(30.0) | 7(70.0) | | | |
| Employment status | Unemployed | 47(24.1) | 148(75.9) | 77.777 | 3 | 0.000 |
| | Part time | 32(62.8) | 19(37.2) | | | |
| | Full time | 1(5.6) | 17(94.4) | | | |
| | Self employed | 4(3.3) | 117(96.7) | | | |
| Employment status of caregiver | Unemployed | 69(19.7) | 281(80.3) | 9.99 | 1 | 0.002 |
| | Employed | 15(42.9) | 20(57.1) | | | |
| **B: Reach with DREAMS** | | | | | | |
| Heard of DREAMS | No | 5(50.0) | 5(50.0) | 4.78 | 1 | 0.000 |
| | Yes | 79(21.1) | 296(78.9) | | | |
| How you heard about DREAMS | CBO/NG O | 8(25.8) | 23(74.2) | 17.018 | 4 | 0.002 |
| | LC | 4(10.3) | 35(89.7) | | | |
| | VHT | 15(18.5) | 66(81.5) | | | |
| | Word of mouth | 37(19.7) | 151(80.3) | | | |
| | Other | 20(43.5) | 26(56.5) | | | |
| Ever been invited to DREAMS | No | 8(40.0) | 12(60.0) | 4.088 | 1 | 0.043 |
| | Yes | 76(20.8) | 289(79.2) | | | |
| Ever been enrolled on DREAMS | No | 8(27.6) | 21(72.4) | 0.612 | 1 | 0.434 |
| | Yes | 76(21.4) | 280(78.7) | | | |
| Year of Enrolments | No | 10(30.3) | 23(69.7) | 12.421 | 8 | 0.133 |
| | 2016-2017 | 0(0.0) | 12(100.0) | | | |
| | 2017-2018 | 0(0.0) | 8(100.0) | | | |
| | 2018-2019 | 0(0.0) | 12(100.0) | | | |
| | 2019-2020 | 1(33.3) | 2(66.7) | | | |
| | 2020-2021 | 1(8.3) | 11(91.7) | | | |
| | 2021-2022 | 8(22.9) | 27(77.1) | | | |
| | 2022-2023 | 38(23.7) | 122(76.3) | | | |
| | 2023-2024 | 26(23.6) | 122(76.4) | | | |
| Age at Enrollment | 10-14years | 32(86.5) | 5(13.5) | 129.215 | 2 | 0.000 |
| | 15-19years | 36(25.4) | 106(74.7) | | | |
| | 20-24years | 6(3.5) | 167(96.5) | | | |
| Know your DREAMS IDs | No | 33(27.1) | 89(72.9) | 3.515 | 1 | 0.061 |
| | Yes | 43(18.5) | 190(81.6) | | | |
| **C: Exposure to DREAMS interventions** | | | | | | |
| C 1. HIV and violence prevention (Journey Plus) | No | 47(15.6) | 254(84.4) | 31.125 | 1 | 0.000 |
| | Yes | 37(44.1) | 47(55.9) | | | |
| C2. Stepping stones | No | 41(50.0) | 41(50.0) | 48.512 | 1 | 0.000 |
| | Yes | 43(14.2) | 260(85.8) | | | |
| C3. No means No - | No | 14(8.4) | 152(91.6 | 30.648 | 1 | 0.000 |
| | Yes | 70(32.0) | 149(68.0) | | | |
| C4. SINOVUYO | No | 45(17.7) | 209(82.3) | 7.362 | 1 | 0.007 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Yes | 39(29.8) | 92(70.2) | | | |
| C5. SASA | No | 22(25.9 | 63(74.1) | 1.056 | 1 | 0.304 |
| | Yes | 62(20.7) | 238(79.3) | | | |
| C6. Apprenticeship | No | 31(47.7) | 34(52.3) | 30.692 | 1 | 0.000 |
| | Yes | 53(16.6) | 267(83.4) | | | |
| C7. Education support | No | 49(16.2) | 254(83.8) | 26.59 | 1 | 0.000 |
| | Yes | 35(42.7) | 47(57.3) | | | |
| C8. Belonging to a group | No | 10(24.4) | 31(75.6) | 0.178 | 1 | 0.673 |
| | Yes | 74(21.5) | 270(78.5) | | | |
| C9. Received DREAMS services in a group | No | 9(23.1) | 30(76.9) | 0.04 | 1 | 0.841 |
| | Yes | 75(21.7) | 271(78.2) | | | |
| C10. HTS screening | No | 12(25.0) | 36(75.0) | 0.326 | 1 | 0.568 |
| | Yes | 72(21.4) | 265(78.6) | | | |
| C11. HIV Testing | No | 21(41.2) | 30(58.8) | 12.915 | 1 | 0.000 |
| | Yes | 63(18.9) | 271(81.1) | | | |
| **SECTION E: Impact** | | | | | | |
| Currently Attending School | No | 35(10.7) | 293(89.3) | 161.394 | 1 | 0.000 |
| | Yes | 49(86.0) | 8(14.0) | | | |
| After graduation | Nothing | 19(35.8) | 34(64.2) | 185.692 | 1 | 0.000 |
| | I continued with my studies | 47(85.5) | 8(14.6) | | | |
| | I dropped out of school | 11(25.0) | 33(75.0) | | | |
| | I got employed | 3(6.1) | 46(93.9) | | | |
| | I got married | 1(1.4) | 70(98.6) | | | |
| | Started own business | 3(2.7) | 110(97.4) | | | |
| DREAMS changed my life | No | 12(26.7) | 33(73.3) | 0.702 | 1 | 0.402 |
| | Yes | 72(21.2) | 268(78.8) | | | |

***Source:*** *Field survey, October 2025*

## Multivariate Logistic Regression Analysis

Multivariable logistic regression analysis was performed to determine the variables independently associated with risky sexual behaviors among AGYW while statistically controlling influence of potential confounders simultaneously in the model. The Computed Adjusted Odds Ratio (AOR) with 95% Confidence Interval (CI) and conventional p-value of 0.05 to determine whether to reject or fail to reject the null hypothesis. Marital status, education status (in school), Age at enrollment, Journeys plus and graduation status (Employment, marriage and starting own business) were the independent variables identified in the logistic regression model significantly associated with RSBs. Marital status had influence on RSBs as those AGYW that were not in union were significantly less likely (AOR = 0.17, 95% CI [0.04-0.67], p-value=0.010) to engage in RSBs compared to those that were in union and this was true in both bivariate and multivariable logistic regression analysis. Relatedly, AGYW that were in school were significantly less likely (AOR=0.001,95% CI [0.000-0.003], p<0.001) to engage in RSBs compared to those that had never been in school. While AGYW out of

school had 1.25 times more likely to engage in RSBs, this was statistically insignificant (p-value=0.803) compared to those who had never been to school.

Conversely, Age at enrollment was a significant predictor for RSBs as those AGYW who were enrolled in the age band of 20-24 years had 49.5 times more likely (AOR = 49.52,95% CI [1.24-1981.93], p-value= 0.038) while who were in the age band of 15-19 years were 42.7 times more likely (AOR = 42.69, 95% CI [1.40-1301.27], p-value= 0.031) to engage in RSBs compared to AGYW in the age band of 10-14 years and this was statistically significant. In addition, AGYW who received Journeys plus were 28.6 times more significantly likely (AOR = 28.59, 95% CI [1.32-618.40], p-value=0.033) to engage in RSBs compared to those who did not receive the intervention. Graduation from the program was significantly associated with RSBs except for those who dropped out of school which was not significant. AGYW who started their own business Started own business (AOR = 17.645, 95% CI [1.799-173.067], p-value= 0.014), got employed (AOR= 18.989, 95% CI [1.416-254.561], p-value = 0.026), and those who got married (AOR=22.392, 95% CI [1.445-346.960], p-value = 0.026) were more likely to engage in risky sexual behavior compared to AGYW without graduation outcome and this was statistically significant. In contrast, AGYW who dropped out of class after graduation had twice the likelihood (AOR = 1.838, 95% CI [0.331-10.189], p-value = 0.486) to engage in RSBs compared to those without graduation outcome and this was statistically not significant.

Finally, pregnancy status (p-value = 0.852), Part time employment (p-value = 0.974), full time employment (p-value = 0.888), self-employment (p-value = 0.872), employment status of care (p-value = 0.609), the way AGYW heard about the program from Local council (p-value = 0.064), VHT (p-value = 0.482), Word-of-mouth (p-value = 0.096) and other sources (p-value = 0.467) Stepping Stones (P-value = 0.144), No means No – Female curriculum (p-value = 0.087), SINOVUYO (p-value = 0.634), Apprenticeship (p-value = 0.770), Education support (p-value = 0.056) and HIV Testing (p-value = 0.574) and currently attending school were all insignificantly associated with risky sexual behaviours (Table 4).

**Table 4.** Multivariate Logistic Regression Showing Association between Predictor Variables and Risky Sexual Behaviours among Adolescent Girls and Young Women

| Variable | Categories | Adjusted Odds Ratio (AoR), [CI] | p-value |
|---|---|---|---|
| **A: Social Demographics** | | | |
| Age group | 15-17years | 1 | 1 |
| | 18-24years | 2.197[0.199-24.222] | 0.520 |
| | 25+years | 1.764[0.096-32.413] | 0.702 |
| Marital status | In union | 1 | 1 |
| | Not in union | 0.167[0.043-0.647] | 0.010 |
| Education Status | Never been in school | 1 | 1 |
| | Out of school | 1.246[0.222-7.001] | 0.803 |
| | In_school | 0.001[0.000-0.003] | 0.000 |
| | Completed School | | |
| Pregnancy status | No | 1 | 1 |
| | Yes | | |

| | | | |
|---|---|---|---|
| | Not sure | 1.303[0.081-20.940] | 0.852 |
| Employment status | Unemployed | 1 | 1 |
| | Part time | 0.967[0.126-7.426] | 0.974 |
| | Full time | 1.275[0.044-37.029] | 0.888 |
| | Self employed | 0.849[0.115-6.270] | 0.872 |
| Employment status of caregiver | Unemployed | 1 | 1 |
| | Employed | 0.684[0.160-2.926] | 0.609 |
| **B: Reach of DREAMS** | | | |
| Heard of DREAMS | No | 1 | 1 |
| | Yes | | |
| How you hear about DREAMS | CBO/NGO | 1 | 1 |
| | LC | 14.239[0.854-237.341] | 0.064 |
| | VHT | 2.405[0.208-27.774] | 0.482 |
| | Word-of-mouth | 6.194[0.724-52.972] | 0.096 |
| | Other | 2.689[0.187-38.655] | 0.467 |
| Ever been invited to DREAMS | No | 1 | 1 |
| | Yes | | |
| Age at Enrollment | 10-14years | 1 | 1 |
| | 15-19years | 42.688[1.400-1301.273] | 0.031 |
| | 20-24years | 49.521[1.237-1981.930] | 0.038 |
| **C: Exposure to DREAMS interventions** | | | |
| HIV and violence prevention (Journey Plus) | No | 1 | 1 |
| | Yes | 28.593[1.322-618.402] | 0.033 |
| Stepping Stones | No | 1 | 1 |
| | Yes | 0.1769[0.0173-1.810] | 0.144 |
| No means No - | No | 1 | 1 |
| | Yes | 0.243[0.048-1.228] | 0.087 |
| SINOVUYO | No | 1 | 1 |
| | Yes | 0.745[0.222-2.499] | 0.634 |
| Apprenticeship/vocational skills | No | 1 | 1 |
| | Yes | 1.453[0.119-17.694] | 0.770 |
| Education support | No | 1 | 1 |
| | Yes | 5.364[0.960-29.981] | 0.056 |
| HIV Testing | No | 1 | 1 |
| | Yes | 0.484[0.039-6.080] | 0.574 |
| **SECTION E: Impact** | | | |
| Currently Attending School | No | 1 | 1 |
| | Yes | 840000000[.-.] | . |
| After graduation | Nothing | 1 | 1 |
| | I continued with my studies | 3350000000[.-.] | . |
| | I dropped out of school | 1.838[0.331-10.189] | 0.486 |
| | I got employed | 18.989[1.416-254.561] | 0.026 |
| | I got married | 22.392[1.445-346.960] | 0.026 |
| | Started own business | 17.645[1.799-173.067] | 0.014 |

***Source:*** *Field survey, October 2025*

## Summary of Participants' Perceptions on Multifaceted Interventions and Risky Sexual Behaviours

Results from quantitative analysis indicated some variations from results of FGD and KII interviews related to MIs and variables of impact associated with RSBs. The findings from qualitative analysis revealed major outcomes in nine (9) themes which had influence on risky sexual behaviours and these included, HIV prevention and sexual health, economic empowerment and livelihood, behaviour change, protection from sexual exploitation and risky sexual relationships, program accessibility and employment opportunity, inclusion of partners and community, family planning services and prevention of pregnancy. During the interviews, respondents were asked questions about their experience on DREAMS and how the program impacted their lives and different responses were highlighted below.

In this present study, it was observed that AGYW were equipped with knowledge and skills in HIV prevention and understood the benefits of testing for HIV every three months and sexual wellbeing.

> "*DREAMS has transformed my life, as I am no longer the same person I was when I first joined. Initially, I had not considered getting tested for HIV, nor was I aware of the comprehensive information regarding it. However, with the arrival of DREAMS, I learned how to safeguard myself against HIV. This knowledge was life-changing, as I discovered the importance of getting tested every three months to understand my status",* (FGD Female respondent, Kafundezi).

Likewise, AGYW highlighted that those who had multiple sexual partners reduced them to remain with only one partner as a measure of preventing HIV.

> *"DREAMS changed my life, before it came I had about 5 boyfriends, but when I joined DREAMS and they asked us to bring our boyfriends so that they are tested, I had to drop all the others and remain with one",* (FGD Female respondent, Kitenga).
>
> *"In my experience, I had numerous boyfriends. Whenever a man would call out to me while I was on my way, I would immediately approach him. If that man or boyfriend requested to engage in sexual intercourse, I found it difficult to decline and would often acquiesce without hesitation. However, upon joining the DREAMS programme, everything changed",* (FGD Female participant, Kitenga).

In addition, AGYW received vocational skills training in different trades to enable them to start their own businesses for economic empowerment.

> *"The programme skilled the AGYWs so that they can be able to start up their own businesses* ", (FGD Female participant, Ssekanyonyi).

It was further emphasized that they became economically empowered when they started earning their own money from their businesses.

> "*DREAMS has helped me because I am able to make shs10,000 on my own other than asking someone",* (FGD participant, Kitenga).

Furthermore, AGYW were equipped with knowledge and skills in financial literacy and learnt how to save money as a way of eradicating poverty.

> "*DREAMS taught us how to save money so that we can use that money later and avoid poverty at home. If I save money, I am able not to beg for money from the male partner. From my experience with DREAMS, I realized that I was unable to save even shs500. Whenever I received shs 500, my only thought was to spend it on food. Yet DREAMS educated us on the value of saving. If you earn Shs 500, you can*

*either save it or set aside a portion. Similarly, if you have shs1000, you can also save some, and when you eventually withdraw it, you can purchase something of value instead of consuming it all at once. This way, you avoid the situation where you find yourself wanting something later but lacking the funds, which could lead to engaging in prostitution,* (FGD respondent, Kafundezi).

Conversely, AGYW changed their behaviour which was attributed to Curriculum Based Interventions (CBIs) received on the program.

*"What I like about the DREAMS project, there are so many, but I am going to highlight a few. First, it is about the interventions, mainly the curriculum for the AGYW. This is No Means No and stepping stones. These curricula have supported girls to change their behaviours. They bring awareness for the girls to know how the world is moving. You know these girls are from the villages, they do not know how HIV spreads. But using these curriculums, these girls have gained knowledge with my assessments to know how HIV is spread and how they can prevent themselves from acquiring the diseases"* (Social worker KII participant, Kibalinga- Mubende).

Similarly, AGYW were empowered with life skills of assertiveness from CBI training and learnt to be determined and resilient.

*"Determination, I would have feared beginning with something small because I was concerned that my colleagues, or even society, would ridicule me. However, I found the courage to believe that I can achieve this. Furthermore, it is not accurate to assume that every man who stands before you and professes love truly means it. When we enrolled in DREAMS, we held the belief that when a girl says 'NO,' she means 'YES.' However, through the training we received in DREAMS, I learned to assign true meaning to my words; when I say 'NO,' I genuinely mean it. I am no longer shy as a young girl; I can now stand in the community and advocate for myself".* (FGD participant, Ssekanyonyi).

Conversely, Adolescent girls (10-14 years) were empowered with skills in re-usable pad making during Journeys plus training which enhanced menstrual hygiene management.

*" It is true the programme changed the girls. School dropouts were reduced because if a child could not be able to complete primary seven and yet the programme has facilitated her with the school fees, with the scholastic materials the girls will be able to complete at least primary level. Then missing school was also reduced because they used to miss because they lacked sanitary pads. But at least they can make their own reusable pads. Then there are also change makers in their communities",* (FGD participant, Mityana).

AGYW became engaged in constructive work in the community and were no longer idle and this prevented them from being sexually abused by men.

"*The few activities that I saw is that the programme taught the AGYWs the skills of tailoring, plaiting hair, baking specifically making cakes is it what they call cookery, it was my first time to see one of the groups making books, this made me happy in that instead of the girl child moving around the community and get involved into relationships with the male counter parts, the programme instead made the AGYWs to meet in one place and do something constructive other than*

*moving aimlessly in the community",* (KII LC1, Ttamu Division, Mityana).

It was highlighted that the number of girls dropping out of school reduced attributed to DREAMS initiative hence improving education retention**.**

*'The DREAMS project has reduced the number of school dropouts. Because it has been providing scholastic materials and school fees for these girls so that they can sustain in schools. They have been paying for a full year. For a girl and provide scholastic material",* (FGD Female Participant, Wabigalo).

On the other hand, the program supported AGYW who were on the verge of dropping out of school to continue schooling.

*"Yes, she possesses the necessary skills, and we were inclined to send one of my daughters as well. She became involved in the DREAMS programme in a different community, specifically Kabulamuliro, which is situated in Busunju. Our daughter has actively participated in the programme, which evidently indicates its value. Even now, she continues to attend the DREAMS programme while also managing her school commitments. The changes are there, since we are not the ones who are staying with her right now, but the change is there and she is still going to school. Right now, she is in senior two",* (KII Male, Partner, Ttamu).

The program enabled the beneficiaries to gain employment, acquire property and become popular in the community.

*"In a way that, for me, when the project came, I had no job. By then, I was selected by the chairperson of my village to mobilize fellow girls. So, after mobilizing my fellow girls, I was selected to be a facilitator for my fellow girls and being a facilitator, I had to be facilitated for delivering the intervention among the AGYWs. So, it became like I had gotten a job, and I got a chance to be known by the community. Because in some areas, I wasn't known, but because of the DREAMS project, I am known everywhere, even at the district level. I have become popular because of the DREAMS project. And there are some good things I have achieved. I managed to buy plots of land because of the DREAMS project. And I managed to build my house where I am now because of that project. So, they met my expectations. I didn't expect that one day I would also have my own house as a result", (*FGD Female participant, Wabigalo**).***

The theory of Social-Ecological Model (SEM) was employed during service delivery which acknowledges that behavior change is influenced by the environmental factors (external and internal). DREAMS partnership did not only empower the primary beneficiaries but also provided contextual services to male partners to prevent HIV among AGYW and household empowerment as revealed by participants from FGDs and KIIs.

*"The project did not aim only at the AGYWs, but also their partners. So, there were even some services that were provided to the AGYW partners, mostly the married and those who were in the transactional sex workers. So, they were tracking their partners and partners tracked were provided with services like VSLA, HPS and condom provision and promotion. And sensitized about GBV and family planning services ", (*Female Participant, FGD Wabigalo).

The participants highlighted that the program was about provision of family planning services to prevent them from getting unintended pregnancies.

*"Yes, I have also gained significant advantages from the programme, as I was previously unaware of how to safeguard myself against contracting the HIV virus, how to prevent unintended pregnancies, and how to avoid giving birth to children whom I would be unable to care for. However, with the advent of the programme, I received assistance; through such training, my understanding was greatly enhanced, and I received substantial support. I was once an individual who lacked knowledge about family planning, but since that time, I have acquired valuable insights on the subject. Currently, my child is seven years old. Furthermore, another benefit of the programme is that all my children are now able to attend school. Prior to the programme, I faced financial constraints, but through the training provided by DREAM regarding HIV protection and family planning, I have learned a great deal, and I am immensely grateful to DREAMS for the assistance it has provided me",* (FGD Female participant, Kafundezi).

Social Asset building was among the primary interventions provided to the AGYW when they convened at safe spaces to receive services in a group and support each other through peer networks as emphasized by the key informant and had this to say,

*"They stay in group, so they have learned from each other", (*KII, Social worker-Mityana).

Finally, girls who graduated from the program were transformed and became role models in the community

*"Very many. For instance, let me illustrate with my wife, who is close to me. When I enrolled her in the DREAMS program to acquire new skills, even though I did not establish a tailoring business for her, she adopted a different approach compared to those in our neighborhood who did not participate in the DREAMS program. Their skepticism was evident as they questioned, "Will she learn the skills, and once she acquires them, will she be able to apply what she has learned?" Now, she stands out as she has gained numerous skills that they currently lack. She can approach her colleagues who were also involved in the project and inquire, "What are you learning now? I struggled with this and that." Moreover, when she gets an opportunity to bake for a small event, such as a birthday, she can prepare the cake for that occasion. Do you not recognize that she is entirely different from those who did not undergo the training.", (*KII, Male partner Ttamu Division).

## Discussion

Risky sexual behaviour (RSB) among AGYW continues to be global health challenge resulting into new cases of HIV infections, other Sexually transmitted diseases (STDs), unintended pregnancies and unsafe abortions. Despite the efforts to avert new HIV infections in Uganda, studies have shown that AGYW (15-24 years) continue to engage in RSBs increasing their risk to acquisition of new HIV infections. In addition, there is scanty or no evidence in literature to show impact of the MIs on addressing RSBs among AGYW post-graduation. Failure to address RSBs will hamper the ongoing efforts to achieve epidemic control and Sustainable Development Goal 3 to end AIDS as a public health threat by 2030. This study aimed to investigate the effectiveness of MIs on reduction of risky sexual behaviours among adolescent girls and young women in Mubende region, Uganda. The main specific objectives of focus were 1) to assess the Reach of MIs among AGYW and 2)

to investigate the influence of MIs on risky sexual behaviors among AGYW. We conducted a survey on 385 respondents with an attempt to establish the relationship between MIs and risky sexual behaviours among adolescent girls and young women.

In this study, we observed that 58% of the participants were in the age group (18-24 years) indicating that the younger age group (15-17 years) was still in school and the older age could have relocated to other places either for marriage or better employment opportunities. The majority (60%) were in union reflecting the true picture of Ugandan girls in that age category after dropping out of school are married off. Large proportion (68.1%) were out of school since the girls who had dropped out of school upon screening were eligible for enrollment on the program due to their level of vulnerability and were at substantial risk for acquisition of HIV infection. Half of the respondents (50.7%) were unemployed and 31.5% were in self-employment. Majority of the respondents' care givers (90.9%) were unemployed but earning a living as peasants and doing small businesses in their communities.

In addition, the results from the current study showed that almost all the participants (97.4 %) had heard about DREAMS program. Large proportion of the participants (94.8%) were invited to the program and 92.5% were enrolled on the program and these findings were not in agreement with the program results where implementing partners had reached 85% of AGYW in their SNUs with core services and of those, 86% received specific services based on their unique needs [12]. It was observed that (41.6%) were in the cohort (2022-2023), perhaps AGYW who had graduated in the first cohorts matured and shifted from their areas of residence either for marriage or better employment opportunities. Almost half (49.2%) were in the age band (20-24 years) at enrollment this is because majority were in committed relationships and had dropped out of school. Furthermore, 40.3% were in the age band of 15-19 years and (10.5%) were in the age band of 10-14 years.

Majority (83.1%) received Vocational skilling, this supports the finding in this study that majority were in the age category (15-24 years) and were out of school. This was the eligibility criteria for provision of Vocational skills training. Majority of the participants (78.7%) did not receive education support and these results are consistent with the findings in this study that the majority of the participants were out of school at the time of enrolment and the services targeted the most vulnerable girls to enable them stay in school Conversely, 87.5% received HTS screening and of those who were screened (86.8%) received risk based HTS which implied that the category of AGYW (15-24years) were enrolled with risk factors of HIV infection and had to be tested for HIV. This finding resonates with UNAIDS update which revealed that globally the prevalence of HIV among AGYW (15-24 years) globally was higher compared to that of the adolescent boys and young men in the same age band [5]. The finding was synonymous with similar study which indicated that adolescent girls and young women from SSA aged (15-24 years) remain at substantial risk of acquiring HIV infection [15]. Additionally, we observed that large proportion of respondents (85.2%) were not attending school and this was not surprising because dropping out of school is a structural driver that increases the level of vulnerability for acquisition of HIV infection.

Furthermore, results in this study revealed that marital status, Education status (being in school), age at enrollment, Journeys plus, gaining employment, marriage & starting own business after graduation were the major determinants significantly associated with risky sexual behaviours. Marital status was found to be significantly associated with RSBs in both bivariate and multivariate analysis whereby AGYW that were not in union were significantly less likely (AOR=0.17, 95% CI:

0.04-0.64) to engage in RSB compared to those that were in union. This observation resonates with the finding in Nigeria which revealed that AGYW cohabitating and those who ever married engaged more in risky sexual behaviours than those who have never married [7]. Contrary to the current research, the findings in Uganda by [16] revealed that married or cohabiting was associated with a lower likelihood of risky sexual behaviors.

Relatedly, AGYW that were in school were significantly less likely (AOR=0.001, p-value=0.000) to engage in RSBs compared to those that had never been in school. While AGYW out of school had 1.25 times more likely to engage in RSBs and this was statistically insignificant (p-value=0.803) compared to those who had never been to school**.** The finding in this current study could be attributed to the school programs which do not give room for the learners to have a lot of free time to engage in risky sexual behaviours. A case in point is during the pandemic of COVID 19 and country wide lockdown as well as long closure of schools, countries registered many teenage pregnancies attributed to RSBs. This is supported by [17] observation in Uganda which revealed that during the peak of the pandemic and extended countrywide lockdown, there were over 60 girls who got pregnant because of the extended closure of schools.

Additionally, girls who are in school receive sex education which enables them not to engage in RSBs unlike those out of school. This observation is further substantiated in the previous study in Nigeria [7] which revealed that as the level of education increases the risky sexual behaviour reduces, this could be because sex education and adolescents´ access to adequate information increase as they get more education.

Conversely, Journeys plus curriculum was significantly associated with risky sexual behavior as AGYW who received Journeys plus were 29 times more significantly likely p=0.033) to engage in RSBs compared to those who did not receive the intervention. This observation is not congruent with the previous study in south Africa [18] which revealed that curriculum-based interventions are perceived to be effective way of preventing HIV and AIDS among the target population. Similarly, the findings in the previous research further revealed that the students have a need to attend life skills workshops because they believe that life skills training will assist them to be assertive and practice behaviors which reduce their level of vulnerability to HIV acquisition [18]. Likewise, the quantitative results in this study indicated significant association between Journeys plus and risky sexual behaviours which were reinforced by qualitative themes from FGDs and KII highlighting behaviour change.

Additionally, Age at enrollment was a significant predictor for risky sexual behavior as those AGYW who were enrolled in the age band (20-24 years ) had 49,5 times more likely (AOR= 49.52,95% CI [1.24-1981.93], p-value= 0.038) as those who were in the age band of 15-19 years were 42.7 times more likely (AOR= 42.69, 95% CI [1.40-1301.27], p-value= 0.031) to engage in RSB compared to those in the age band of 10-14 years. The findings in this study are consistent with [5, 15] which indicated that AGYW in the age category (15-24 years) are sexually active and at higher risk of acquisition of HIV infection.

We observed that AGYW who started their own business after graduation from the program had 18 times higher likelihood of engaging in risky Sexual behaviours compared to those who did nothing after graduation. While the association was statistically significant, the high odds suggest that for this sample of AGYW who started their own business were more likely to engage in RSBs. Whereas theory and empirical evidence from previous studies [19] elsewhere in the world revealed that economic empowerment among AGYW had significant impact of girl empowerment on

risky sexual behaviours and adolescent pregnancy, this was not consistent in this current study. The findings in this study might have alternative explanations. The sample size of AGYW who started their own business after graduation and engaged in RSBs might be small or highly unpredictable risk. Starting business requires initial capital and after starting the business the profits may not be enough for household income and this might have forced the AGYW to engage in transactional sex either to get initial capital or to supplement on household income. Though there has been less rigorous research done to explore the strength of linkage between economic empowerment and risky sexual behaviours among AGYW. The finding in this study was synonymous with the results from the qualitative study in Tanzania by [20] that providing economic resources to AGYW through cash transfers without ensuring self-agency is unlikely to be an effective long-term intervention for economic empowerment.

In contrast, the findings in the previous study in Uganda by [21] examined the effect of economic assets on sexual risk-taking intentions, the results indicated that having access to economic assets plays an important role in influencing adolescents' sexual risk-taking intentions. It was further observed that AGYW who got employed after graduation had 19 times higher likelihood of engaging in risky sexual behaviours compared to those who did nothing after graduation. While the association was statistically significant, the high Adjusted Odds Ratio suggests that for this sample of AGYW who got employment were more likely to engage in RSB as opposed to safe sexual behaviours. This area requires further research. The finding in this study is surprising because employment can result into financial independence and disposable income reducing dependence on men and vulnerability for HIV infection. However, employment can have negative impact to increase opportunities of travel to socialize and engage in social activities leading to risky sexual behaviours. In addition, another explanation for the inconsistency in the findings could be the small sample of AGYW who got employed after graduation from the program and engaged in RSB or the risk which is highly unpredictable. This observation was consistent with the results in the previous research by [7] in Nigeria.

Furthermore, the finding in this study indicated that getting married after graduation from the program had 22 times likelihood of engaging in RSB than those who did not get married. This was Substantiated by [7] in Nigeria whereby adolescent who are married had the highest percentage (42.8%) of risky sexual behaviours, while cohabiting young women had the highest percentage (30.1%) of the risk among their cohort.

Conversely, girls who dropped out of class after graduation in this study had twice the likelihood (AOR=1.89, p-value= 0.486) to engage in risky sexual behavior compared to those who had not dropped out of school. This finding is consistent with [22] in Uganda which revealed that the adolescents had 1.3 times high likelihood to engage in RSBs compared to those who were not dropouts. Similarly in another previous study in selected secondary schools in Uganda, the results also showed that about 50.1% prior engagement in sexual behaviours was associated with school dropouts. A significant association between school dropout and engagement in sexual risky behaviours was confirmed ($p = 0.001$).

On the other hand, Employment status was not significantly associated with RSBs in this study, and this was surprising because poverty is a structural driver for acquisition of HIV infection. This observation was consistent with the finding in previous study in Uganda by [23] which revealed that female adolescents who were working but received no pay, self-employed in agriculture and who did manual jobs, whether skilled or not had significantly higher odds of reporting STIs compared to female adolescents who were not employed.

Conversely, female adolescents who had two or more lifetime sexual partners had significantly higher odds of reporting STIs than those who had only one lifetime sexual partner [23]. This area requires further research.

Furthermore, employment status of care givers had no significant relationship with RSBs in this study. However, household income can influence risky sexual behaviors because AGYW in poor families find it difficult to attain education and therefore tend to engage in transactional sex or commercial sex to look for survival and sometimes they are married off early by their care givers. The observation in this current study is consistent with the findings in the previous study by Ewemooje [7] which revealed that employment status was not associated with RSBs.

Finally, Curriculum based interventions (CBIs) except Journeys plus were independently not associated with RSBs. This finding could have been affected by the fact that services were tailored to age band and the participants who were not eligible for that service could have been considered not to have received the intervention during analysis. Although stepping stones methodology aims at promoting sexual health, improve communication skills, address issues of gender inequality and prevent HIV the results in this current study were not comparable with the findings in India [24] which revealed that there were significant changes in their relationships after training, benefit from discussion of gender, sexuality, condom use and HIV vulnerability issues.

## Conclusion

The current study assessed the Reach of multifaceted interventions and investigated the influence of multifaceted interventions on risky sexual behaviors among adolescent girls and young women. The study revealed that 92.5% of the target population were reached by DREAMS programme. Multifaceted interventions had influence on reduction of risky sexual behaviours in this study. Uptake of multifaceted interventions was average across the different interventions in the region. There was evidence of behaviour change attributed to DREAMS interventions. In addition, marital status, education status (in school), Age at enrollment, Journeys plus, gaining employment, marriage and starting own business after graduation were the major determinants significantly associated with risky sexual behaviours. HIV prevention and sexual health, economic empowerment, behaviour change, employment opportunity, reduced unintended pregnancies, retention in school and asset building were identified as the major outcomes achieved by the program. Furthermore, skilling girls in apprenticeship and providing startup kits does not immediately translate into behaviour change, there is need for the implementers and different stakeholders to follow up the AGYW after graduation and continue with business coaching for sustainable and better health outcomes. Finally, findings in this study provided insights to develop strategies for school retention, sustainable skilling model, risk reduction measures among young women in union and policy development.

## Strengths and Limitations

This study encountered several shortcomings and strengths. The study employed mixed-methods design combined with quantitative and qualitative data collection and analysis for triangulation. The relatively large sample size of 385 respondents strengthened reliability of quantitative findings. In addition, the use of multivariate analysis allowed identification of independent association between variables. Language barrier was addressed through translation of the questionnaires and interview guides in local language and were administered by research assistants. The inclusion of program officers, district community development officers and social workers as key informants and

Facilitators in FGDs provided in-depth perspectives from those that directly implemented the program. The cross-sectional study design which hampers causality and restricts findings on association and none-response on sensitive questions on sexual activity, but this was minimized by recruiting same gender as research assistants though not all were females. Finally, the small samples for the previous cohorts limited comparison of risky sexual behaviours between different cohorts of enrollment.

## Competing Interests

The authors have declared that no competing interests exist.

## Ethical Approvals

The Investigator maintained Ethical practices and principles of research ethics recommended in research involving humans as research subjects throughout the entire research process. Permission was sought from all relevant bodies and institutions prior to data collection. Introductory letter was obtained from Texila American University to seek for permission to carry out research in Mubende region. Administrative clearance was sought from Baylor Foundation Uganda to conduct the study. Ethical approval was sought from Gulu University Research Ethics Committee (GULU-REC, REF GUREC-2025-867) and Uganda National council for science and Technology (UNCST-REF-HS6319ES) to conduct the study. Clearance from District Health offices to conduct the study from the sub counties of Mubende and Mityana districts was obtained prior to data collection. Information was provided to the sub counties before data collection. Participants' rights were respected to make their own informed decision to participate in the study by providing full information about the study.

## Authors Contributions

MI was involved in conceptualization, design, data curation, formal data analysis, investigation, supervision, methodology, validation, drafting original paper, reviewing and editing and final approval for publication. Both NG and SO were involved in conceptualization, design, investigation, reviewing and editing, supervision and final approval of the manuscript for publication.

## Recommendations

This study is the first of its kind in Uganda and Mubende region, therefore further research that employs Randomized Control Trial (RCT) study design and the use of RE-AIM framework to evaluate the effectiveness and efficiency of MIs on RSBs. There is need for the implementers and different stake holders to follow up the AGYW after graduation for sustainable and better health outcomes. Involvement of adolescent boys and young men in the provision of secondary and contextual services can facilitate behaviour change among AGYW. There is need for the Government of Uganda to address the issue of school dropouts and ensure the AGYW given education support are monitored to complete the education cycle. The Ministry of Education and District education offices should come up with better and sustainable strategies to minimize dropouts of students.

To address the vice, there is need to ascertain individual, family and school based contributing factors to this surge and ensure strategies are put in place along those lines. Startup kits should be for the individual girl and not for the group and mechanisms should be put in place to ensure the girls are supported to start up their own businesses. Furthermore, involvement of male partners and care givers to form VSLA groups can create a more sustainable approach which can enable AGYW to save and pool their own resources to start their own businesses to improve their household income. There is need to district to continue engaging mentors for business coaching to enable AGYW to perfect their businesses. Additionally, there is need for the

government of Uganda to integrate DREAMS interventions in schools, health facilities and youth groups, for strengthen partnerships with all stakeholders in the ministry of health, Ministry of education, Ministry of gender, Labour and social development, civil society organizations, DHTs, community leaders, religious leaders and cultural leaders for multi-sectoral approach, efficient and sustainable AGYW programming. Finally, social media such as twitter, Facebook, WhatsApp, Tiktok among others, considering their influence in society should be adopted by implementing partners and health authorities to disseminate accurate information and address RSBs among AGYW.

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## Data Availability

The data set related to this study has been published in Texila International Journal of Public Health.

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# Blockchain-Enabled Smart Contract Monitoring and Universal Health Coverage Efficiency for Neglected Tropical Diseases in Nigeria

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***Abstract*** *This study examines the role of blockchain-enabled monitoring systems in enhancing the efficiency of Universal Health Coverage (UHC) for Neglected Tropical Diseases (NTDs) in Nigeria. Despite ongoing policy efforts, UHC delivery remains constrained by fragmented governance structures, weak financial transparency, and limited real-time performance monitoring. Blockchain technology, operationalized through smart contract–based mechanisms, offers a pathway to strengthen accountability, improve resource tracking, and optimize system efficiency. A quantitative cross-sectional design was employed using data from 314 health system stakeholders across three expert groups: UHC and NTD specialists, Healthcare 4.0 and IT experts, and international digital health professionals. Data were analyzed using Principal Components Analysis (PCA), reliability testing, Confirmatory Factor Analysis (CFA), and Structural Equation Modeling (SEM). The model demonstrated strong fit (RMSEA = 0.028; SRMR = 0.043; CFI = 0.99). Findings show that blockchain-enabled monitoring systems significantly influence UHC efficiency, with Blockchain systems (HBC) (β = 0.40) and fund utilization monitoring (β = 0.39) as the strongest drivers. Big data (β = 0.33), fog computing (β = 0.36), socio-cultural acceptance (β = 0.36), and economic readiness (β = 0.39) also showed significant effects. Efficiency gains are driven by integrated monitoring architectures that align governance mechanisms, data infrastructure, and contextual readiness conditions. These findings provide policy-relevant evidence for strengthening transparent and efficient UHC systems for NTD control in resource-constrained settings.*

***Keywords*** *Blockchain, Health System Efficiency, Neglected Tropical Diseases, Nigeria, Smart Contracts, Universal Health Coverage.*

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## Introduction

Nigeria's Universal Health Coverage (UHC) system faces profound efficiency challenges. With fewer than 5% of the population enrolled in the National Health Insurance Scheme, over 70% of healthcare expenditure financed out of pocket, and limited integration of performance monitoring systems, the UHC framework for Neglected Tropical Diseases (NTDs) remains largely reactive and fragmented [1, 2, 9, 17]. Efficiency, encompassing resource optimization, cost control, and system responsiveness, is critical for achieving sustainable NTD elimination within constrained financial and human resource environments. These challenges reflect not only resource limitations but also systemic inefficiencies in governance structures, data visibility, and real-time performance monitoring within the health system [1, 2]. In practice, these inefficiencies reinforce one another, constraining overall system responsiveness and performance.

Blockchain-enabled monitoring systems, a foundational component of Healthcare 4.0, provide a distributed, immutable infrastructure for transparent, secure, and real-time tracking of healthcare transactions, supply chains, funding flows, and intervention performance [3–5, 15, 18]. Through smart contracts, governments and health institutions can automate monitoring processes, reduce leakages, and enhance accountability without reliance on centralized administrative controls [5]. Within this context, blockchain-enabled monitoring systems function as governance mechanisms that restructure coordination, traceability, and oversight across health system operations.

Nigeria's National Information Technology Development Agency (NITDA) identifies blockchain as a key enabler of digital transformation in healthcare, particularly for managing health data and strengthening institutional accountability [6]. This policy alignment provides a relevant basis for examining blockchain-enabled governance within UHC delivery for NTDs in a resource-constrained setting, supported by global digital health strategies [16].

Despite its relevance, the relationship between blockchain-enabled monitoring systems and UHC efficiency for NTDs in Nigeria remains underexplored. Existing studies largely focus on conceptual discussions or high-income contexts, limiting their applicability to Nigeria's institutional and infrastructural realities [3–5, 7, 19]. Furthermore, limited attention has been given to how blockchain systems interact with complementary Healthcare 4.0 technologies and contextual factors influencing implementation. This results points to the need for an integrated analytical perspective that captures the joint influence of governance mechanisms, computational infrastructure, and contextual readiness on efficiency outcomes.

Drawing on Healthcare 4.0 and digital health governance literature [3–7, 16], this study adopts a socio-technical framework in which blockchain-enabled monitoring systems interact with complementary computational technologies (e.g., big data analytics and fog computing) and contextual factors (e.g., socio-cultural acceptance and economic readiness) to influence UHC efficiency outcomes. Within this framework, efficiency is conceptualized as a governance-driven performance dimension shaped by transparency, accountability, and data-enabled coordination.

This study addresses these gaps by employing a quantitative structural equation modeling approach to identify and validate the monitoring mechanisms most strongly associated with efficiency outcomes. The findings contribute to understanding how blockchain-enabled monitoring systems can strengthen transparency, accountability, and coordination within UHC delivery for NTDs in Nigeria. This manuscript is derived from a broader doctoral study that developed and validated an integrated socio-technical

framework linking Healthcare 4.0 to UHC performance outcomes in Nigeria. This study represents a focused sub-analysis of a broader structural model, isolating the efficiency pathway to provide a more granular examination of governance-driven performance mechanisms. By doing so, it provides empirical evidence on how integrated digital health systems translate into measurable efficiency gains in resource-constrained settings.

### Research Objectives

Specific objectives were to: (1) identify variables loading significantly onto UHC efficiency through Principal Components Analysis; (2) to validate the measurement model through Confirmatory Factor Analysis; (3) estimate structural path coefficients using Structural Equation Modeling (SEM); and (4) discuss the implications of the findings for Nigeria's health system digitalization strategy.

These objectives operationalize the empirical testing of governance, computational, and contextual determinants of efficiency within a unified analytical framework [8].

## Materials and Methods

### Design and Sample

A quantitative cross-sectional survey design was employed. Data were collected from 314 health system stakeholders across three expert groups: Group A: UHC and NTD specialists in Nigeria (n = 111); Group B: Healthcare 4.0 and IT specialists in Nigeria (n = 100); and Group C: international Healthcare 4.0 experts (n = 103). Stratified purposive sampling ensured balanced domain representation. The sample size exceeds the recommended minimum of 200–250 observations for SEM stability [8].

This study is derived from a broader doctoral research project in which the conceptual framework and structural relationships were developed and validated using LISREL-based multivariate analysis. This sub-analysis specifically focuses on the efficiency pathway within the broader socio-technical framework, examining governance, computational, and contextual determinants of UHC performance.

### Measurement Instrument

A structured questionnaire measured each variable on a five-point interval scale (1 = Very Low to 5 = Very High). Variables in the efficiency domain included 10 blockchain-based smart contract monitoring items, 9 general Healthcare 4.0 technology items, and 5 contextual moderator items, consistent with the initial theoretical framework. The instrument was validated through a 15-respondent pilot study prior to full deployment. The pilot phase enabled assessment of item clarity, internal consistency, and construct alignment, and informed minor refinements in wording and structure to enhance measurement accuracy and respondent understanding.

### Analytical Approach

Data were analyzed using SPSS and LISREL. Descriptive statistics confirmed data normality (all skewness values $< \pm 0.14$; all kurtosis values within $\pm 2$). PCA with Varimax rotation identified variables loading significantly ($\geq 0.40$) onto efficiency. Cronbach's Alpha assessed internal consistency. CFA validated measurement model fit, and SEM estimated structural path coefficients. Model fit was evaluated using established thresholds: CFI and NNFI $\geq 0.90$ indicate acceptable fit, while RMSEA and SRMR $\leq 0.08$ indicate reasonable approximation error [8].

This sequential analytical procedure reflects a multivariate modeling strategy in which exploratory (PCA), confirmatory (CFA), and structural (SEM) stages are integrated to ensure robustness and validity of the estimated relationships.

The analytical framework is grounded in a socio-technical perspective, where blockchain-enabled monitoring systems, complementary computational technologies (e.g., big data analytics and fog computing), and contextual

readiness factors (e.g., socio-cultural acceptance and economic readiness) jointly influence UHC efficiency outcomes.

## Results

### Reliability and Data Quality

Cronbach's Alpha coefficients were 0.756 (Group 1: NTD/UHC-specific variables) and 0.742 (Group 2: general Healthcare 4.0 variables), both within acceptable ranges. The moderator group yielded $\alpha = 0.649$, which is acceptable for exploratory research [8]. These reliability values indicate satisfactory internal consistency of the measurement scales, supporting their suitability for multivariate analysis [8]. Descriptive statistics confirmed near-normal distributions for all variables, with means clustered around 4.0 (High) and standard deviations between 0.73 and 0.81. Skewness and kurtosis values remained within acceptable thresholds, further supporting the assumption of normality required for SEM estimation [8].

One-sample t-tests further confirmed that mean scores for all variables were significantly higher than the neutral midpoint (3.0) ($p < 0.001$), indicating consistently positive expert perceptions regarding the relevance and applicability of blockchain-enabled Healthcare 4.0 technologies within the Nigerian UHC context.

### PCA: Variables Loading onto Efficiency

Varimax-rotated PCA identified the following variables loading significantly ($\geq 0.40$) onto UHC efficiency: Monitoring of vectors and NTD spread (DSCMVS = 0.572); Monitoring of research and development innovations (DSCMRDI = 0.726); Monitoring of intervention processes (DSCMIP = 0.548); Monitoring of UHC fund utilization (DSCMUFC = 0.507); Monitoring of insurance claims (DSCMIC = 0.598); Healthcare big data (HBD = 0.695); Healthcare blockchains (HBC = 0.465); Fog computing (HFC = 0.753); Socio-cultural acceptance (SCAH4NTDN = 0.869); Economic readiness (ERH4NTDN = 0.656). All retained variables exceeded the minimum loading threshold of 0.40, indicating strong contributions to the latent efficiency construct [8]. These loadings confirm the structural differentiation between efficiency and effectiveness, with computational, financial governance, and social readiness variables predominantly associated with efficiency. This pattern supports the theoretical expectation that efficiency outcomes are primarily driven by governance, monitoring, and computational infrastructure variables rather than by clinical or service-delivery technologies. These results further indicate that efficiency is structurally linked to accountability-driven and data-intensive system functions within the Healthcare 4.0 framework.

### SEM Results: Blockchain Monitoring and Efficiency

The structural relationships of the validated model are presented in Figure 1. The model demonstrated satisfactory goodness-of-fit, consistent with established SEM thresholds ($RMSEA \leq 0.08$; $SRMR \leq 0.08$; $CFI \geq 0.90$), indicating that the hypothesized structure adequately represents the observed data [8]. This structure reflects the underlying socio-technical framework guiding the analysis.

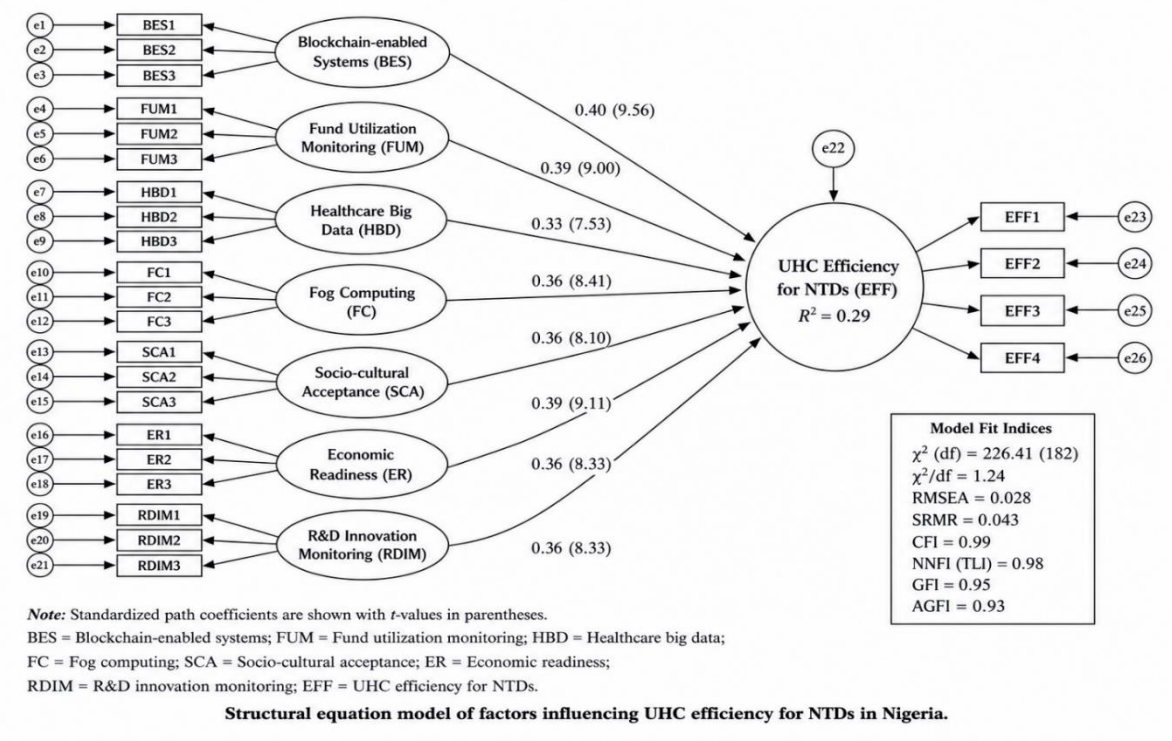


**Figure 1.** Structural Equation Model of Factors Influencing UHC Efficiency for NTDs in Nigeria

*Source: Author's conceptualization and empirical results derived from the doctoral study.*

**Table 1.** Structural Equation Modeling Results: Determinants of UHC Efficiency for NTDs in Nigeria

| Variable | B | $R^2$ | T-value | Key Interpretation |
|---|---|---|---|---|
| Blockchain Systems (HBC) | 0.40 | 0.29 | 9.56 | Primary governance layer; secure data integration |
| Fund Utilization Monitoring (DSCMUFC) | 0.39 | 0.26 | 9.00 | Transparency in NTD fund allocation and expenditure |
| Economic Readiness (ERH4NTDN) | 0.39 | 0.27 | 9.11 | Financial capacity moderates technology efficiency |
| NTD Vector Monitoring (DSCMVS) | 0.40 | 0.26 | 8.88 | Blockchain-enabled vector surveillance |
| Fog Computing (HFC) | 0.36 | 0.23 | 8.41 | Local real-time analytics at care centers |
| R&D Innovation Monitoring (DSCMRDI) | 0.36 | 0.23 | 8.33 | Smart contracts for clinical trials and drug development |
| Insurance Claims Monitoring (DSCMIC) | 0.36 | 0.22 | 8.10 | Blockchain monitoring of NHIS claims processing |
| Socio-Cultural Acceptance (SCAH4NTDN) | 0.36 | 0.22 | 8.10 | User acceptance reduces adoption friction |
| Intervention Processes (DSCMIP) | 0.34 | 0.22 | 8.07 | Government-directed accountability monitoring |
| Healthcare Big Data (HBD) | 0.33 | 0.19 | 7.53 | Infrastructure for advanced analytics and AI |

***Note:*** *β = standardized path coefficient; T-values > 1.96 indicate statistical significance at the 95% confidence level. All paths significant at p < 0.001.*

***Source:*** *Authors' conceptualization and empirical results derived from the doctoral study.*

Detailed structural path coefficients and explanatory power of each determinant are presented in Table 1. All structural paths were statistically significant (T-values > 1.96), indicating strong empirical support for the hypothesized relationships [8]. Blockchain-enabled monitoring systems (HBC) (β = 0.40) and NTD vector monitoring (β = 0.40) emerged as the strongest predictors of efficiency, closely followed by fund utilization monitoring (β = 0.39) and economic readiness (β = 0.39). These findings highlight the central role of governance, financial transparency, and contextual readiness in driving efficiency within UHC systems. The magnitude and consistency of these coefficients suggest that governance-oriented technologies exert a more pronounced influence on efficiency outcomes than purely technical or clinical innovations. The reported $R^2$ values (0.19–0.29) indicate moderate explanatory power, consistent with the multifactorial nature of health system efficiency and suggesting that additional contextual and institutional factors may also contribute to observed outcomes [8]. This level of explanatory power is consistent with expectations in complex socio-technical systems, where multiple interacting determinants shape performance outcomes.

### Correlation Between Effectiveness and Efficiency

The correlation between effectiveness and efficiency was strong (r = 0.93, T = 33.25), indicating that improvements in efficiency are closely associated with gains in effectiveness. This strong relationship suggests that while efficiency and effectiveness are conceptually distinct constructs, they are empirically interdependent within the UHC framework, reinforcing the integrated nature of health system performance outcomes. This interdependence highlights the importance of coordinated system-level interventions that simultaneously address both performance dimensions.

## Discussion

The findings of this study provide robust empirical evidence on the role of blockchain-enabled monitoring systems in improving the efficiency of UHC for NTDs in Nigeria. Blockchain-enabled monitoring systems (β = 0.40) and fund utilization monitoring (β = 0.39) emerged as the strongest predictors, underscoring the central importance of institutional control structures in shaping health system performance. These results suggest that inefficiencies within Nigeria's UHC system are driven not only by resource constraints but also by limitations in oversight, coordination, and financial transparency across system functions [3–5].

Consistent with the descriptive results, the uniformly high mean scores and significant t-test outcomes ($p < 0.001$) suggest strong expert consensus on the relevance of blockchain-enabled Healthcare 4.0 technologies. This indicates that their perceived importance reflects a shared recognition of their potential within the Nigerian health system context.

From a theoretical perspective, the findings support the positioning of blockchain not merely as a technological innovation but as an institutional infrastructure embedded within Healthcare 4.0 systems. This aligns with digital health governance literature, which emphasizes integrating technological capabilities with organizational and regulatory processes to enable system-level transformation [3, 4, 16, 19]. In this study, blockchain-enabled smart contracts function as automated monitoring mechanisms that reduce information asymmetry, minimize resource leakages, and strengthen accountability across fund flows and intervention processes [15, 18]. Their application in healthcare supply chains has also been shown to enhance traceability and improve transparency in resource-limited settings [10].

The PCA results reinforce this interpretation by demonstrating that efficiency is structurally associated with governance-oriented,

computational, and socio-contextual variables. Variables such as fog computing, big data analytics, and socio-cultural acceptance exhibited strong loadings, indicating that efficiency outcomes are shaped by data-intensive and accountability-driven system functions rather than by clinical service delivery components.

The strong contribution of fund utilization monitoring (β = 0.39) highlights the importance of financial traceability in improving efficiency. In contexts characterized by high out-of-pocket expenditure and limited insurance coverage, inefficiencies are often linked to weak financial oversight and delayed accountability mechanisms [11, 12]. Blockchain-enabled monitoring systems address this gap by enabling verifiable and traceable transactions, thereby reducing inefficiencies associated with misallocation, delays, and information asymmetry. However, their effectiveness remains contingent on institutional adoption, regulatory enforcement, and interoperability with existing health information systems.

Complementary computational technologies further reinforce the socio-technical nature of efficiency outcomes. Fog computing (β = 0.36) and healthcare big data (β = 0.33) contribute by enabling decentralized data processing and advanced analytics, supporting continuous data exchange and localized decision-making for NTD interventions in underserved populations [13].

Socio-cultural acceptance (β = 0.36) and economic readiness (β = 0.39) emerged as significant moderating factors, confirming that the effectiveness of blockchain-enabled monitoring systems is conditioned by contextual realities. This finding aligns with socio-technical and technology adoption theories, which emphasize that outcomes are shaped by interactions between technical systems and social environments [7, 20]. Broader digital health adoption challenges in Nigeria—including infrastructural gaps, limited system readiness, and uneven digital literacy—have been widely documented and remain critical considerations for implementation [14].

The SEM results provide strong evidence that governance-oriented technologies exert the most substantial influence on efficiency outcomes, as reflected in the magnitude and consistency of the standardized path coefficients. This indicates that improvements are primarily driven by enhanced transparency, coordination, and accountability mechanisms rather than by isolated technological enhancements.

Although all structural paths were statistically significant, the model's moderate explanatory power ($R^2$ = 0.19–0.29) reflects the inherent complexity of health system performance. Efficiency outcomes are influenced by multiple interacting factors, including governance quality, regulatory enforcement, and institutional capacity, which extend beyond the variables captured in the present model.

The strong correlation between effectiveness and efficiency (r = 0.93) underscores the interdependence of UHC performance dimensions. While analytically distinct, improvements in efficiency appear to reinforce effectiveness, suggesting that system-level interventions should address both dimensions simultaneously.

From a policy perspective, the findings indicate that improving UHC efficiency for NTDs in Nigeria requires a shift from fragmented monitoring approaches to integrated, blockchain-enabled governance architectures. However, large-scale implementation is likely to face practical constraints, including infrastructure limitations, interoperability challenges, regulatory uncertainty, and shortages of skilled human resources. Initial deployment costs may also present barriers in resource-constrained settings, consistent with broader evidence on digital health implementation in LMICs [19].

Overall, this study advances the literature by demonstrating that improvements in UHC efficiency are driven by the interaction of governance mechanisms, computational infrastructure, and contextual readiness. It contributes to a more nuanced understanding of Healthcare 4.0 by positioning blockchain-enabled monitoring systems as embedded governance infrastructures within broader socio-technical systems. Taken together, the findings indicate that meaningful efficiency gains depend on coordinated alignment between technology, institutions, and context rather than on technological adoption alone.

## Limitations

The cross-sectional design limits the ability to establish causal relationships regarding the temporal dynamics of blockchain adoption and UHC efficiency improvements. As a result, the observed associations should be interpreted as indicative rather than definitive evidence of causality.

In addition, reliance on expert responses, particularly among Group B participants in contexts where blockchain-enabled healthcare systems are still in early stages of implementation, may introduce perception bias. The use of self-reported data may also be subject to response bias, potentially influencing the accuracy of reported relationships. This may affect the generalizability of findings to fully operational health system environments where blockchain applications are more mature.

The moderate $R^2$ values (0.19–0.29) reflect the inherent complexity of efficiency as a multifactorial health system outcome rather than model inadequacy. These values are consistent with expectations for socio-technical systems in which multiple interacting institutional, technological, and contextual factors influence performance outcomes.

Furthermore, the study does not fully capture broader institutional and regulatory dimensions, such as governance quality, policy enforcement, and interoperability constraints, which may also influence the effectiveness of blockchain-enabled monitoring systems.

Future research should employ longitudinal designs and incorporate objective administrative data to enable stronger causal inference and validate the observed relationships over time. Comparative multi-country studies across low- and middle-income countries (LMICs) would enhance external validity, while mixed-methods approaches could provide deeper insights into implementation dynamics, governance processes, and contextual adaptation. Additional research should also incorporate institutional and policy variables to enhance the model's explanatory power and provide a more comprehensive understanding of efficiency dynamics within UHC systems.

## Conclusion

The findings of this study provide empirically grounded evidence on the relationship between blockchain-enabled monitoring systems and the efficiency of UHC for NTDs in Nigeria. Blockchain systems (HBC), fund utilization monitoring, economic readiness, and vector surveillance emerged as the strongest predictors, while fog computing, big data analytics, socio-cultural acceptance, and R&D innovation monitoring provided important complementary contributions.

The results indicate that improving UHC performance for NTDs requires a coordinated strategy that integrates blockchain-based governance mechanisms with advanced data infrastructures, sustainable financing structures, and community-level acceptance. These findings suggest that efficiency gains depend on the alignment of governance mechanisms, computational capabilities, and contextual readiness conditions, rather than on isolated technological adoption.

This study provides an empirically validated, context-specific model of Healthcare 4.0 implementation in a low- and middle-income country setting, demonstrating how blockchain-

enabled governance can enhance performance within UHC systems. It advances a socio-technical perspective in which improvements are achieved through the interaction of institutional control structures, computational technologies, and contextual readiness, consistent with established theoretical frameworks on technology adoption and system integration [7, 20].

Overall, the study contributes a pathway-based understanding of digital health transformation, showing that meaningful efficiency improvements are driven by coordinated interactions between technology, institutions, and context within complex health systems.

## Conflict of Interest

The authors declare no conflict of interest. This study was conducted independently as part of doctoral research at Texila American University.

## Ethical Approval

Ethical clearance was obtained from the Texila American University Institutional Review Board (IRB/TAU/2024/H4UHC/002). Informed consent was obtained from all participants. Participant anonymity and data confidentiality were maintained throughout.

## Data Availability

Anonymized study-level data are available from the corresponding author upon reasonable request, subject to institutional approval.

## Author Contributions

- **YYI:** Conceptualization; theoretical framework development; data collection; formal analysis (PCA, CFA, SEM); writing original draft; review, and editing.
- **AOP**: Methodology supervision; critical appraisal of the analytical approach and findings; writing, review, and editing.
- A**LR**: Conceptual refinement; validation of analytical framework; critical review and editing of manuscript.

All authors have read and approved the final manuscript.

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# An Assessment of Mental Health Help-Seeking Behaviours of Adolescents and Young People in Bauchi State, Nigeria: A Cross-sectional Study

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***Abstract*** *Adolescence and young adulthood are critical developmental phases often marked by a high prevalence of mental health issues, including in Nigeria. This study evaluated the prevalence of depression and mental health help-seeking behaviours of adolescents and young people in Bauchi State, Nigeria. A cross-sectional community-based survey was conducted in May 2026 among adolescents and young people aged 15 to 24 years in Bauchi Local Government Area, Bauchi State, Nigeria, using a multistage sampling technique. Quantitative data were collected from 390 participants using a three-part questionnaire that included descriptive statistics, the Patient Health Questionnaire-9 (PHQ-9) to measure depressive symptoms, and the General Help-Seeking Questionnaire (GHSQ, V15) to assess the likelihood of seeking support from various sources. Data were analyzed using SPSS version 26.0, employing descriptive statistics, t-tests, chi-square tests, and ANOVA, with significance set at $p<0.05$. The mean age of respondents was 18.84± 2.59 years. Prevalence of depression using PHQ-9 was 19.2% mild, 58.7% moderate, 15.6% moderately severe, and 2.6% severe. Overall, the mean PHQ-9 score was 11.65±3.6, indicating moderate depression. Young people (20 to 24 years) exhibited significantly higher mean depression scores (12.3±3.6) compared to adolescents (11.2±3.5, $p=0.004$). Overall, adolescents and young people in Bauchi State sought help mostly from their parents/guardians ($\bar{x}=5.58$, $SD=1.076$), siblings/close relatives ($\bar{x}=5.31$, $SD=0.940$), religious leaders ($\bar{x}=5.28$, $SD=1.160$), and close friends ($\bar{x}=5.01$, $SD=1.123$). There was no significant difference in help-seeking behaviours by gender and age group ($p>0.05$); however, the study found that more females sought help from online resources than males ($t=-2.202$, $p=0.028$), and that more males would not seek help ($\bar{x}=4.16$, $SD=1.302$) as often as females ($\bar{x}=3.87$, $SD=1.490$; $t=2.099$, $p=0.036$). While help-seeking behaviours tended to decrease with increasing depression severity, this was not found to be statistically significant ($p=0.0060$). The findings reveal a high burden of depression, with a preference for seeking help from informal sources and religious leaders. Mental health interventions in Nigeria should be decentralized into community and religious structures, while policy efforts should improve community-level identification of depression and strengthen referral pathways for specialized care.*

***Keywords*** *Adolescents, Help-Seeking Behaviours, Mental Health, Nigeria, Young People.*

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## Introduction

Young people account for 24% of the world's population of over 8 billion people [1], with one in six people being adolescents aged 10-19 years [2]. Adolescence and young adulthood are critical transitional phases of human development characterized by rapid social, emotional, and cognitive changes [3]. Nigeria has a young population, with 31% of its estimated 200 million people aged 15 to 24 years [4, 5]. Mental health is a key determinant of overall well-being. The World Health Organization (WHO) defines mental health as a state of well-being in which people can cope with life's stresses, realize their abilities, learn and work well, and contribute to their community [3].

Globally, young people experience the highest prevalence of mental health disorders compared to individuals at any other stage of the lifecycle [6], with up to 20% of adolescents likely to experience mental health disorders [7]. Globally, approximately one in seven adolescents (10–19 years) experiences a mental disorder [3], accounting for 15% of the global burden of disease in this age group [1]. In Nigeria, the prevalence of mental health disorders among adolescents is estimated to range between 10% and 37%, yet these conditions remain largely unrecognized and untreated [8]. Specifically, in Bauchi State, a recent study identified 25.3%, 8.9%, and 0.7% of in-school adolescents with mild, moderate, and moderately severe depression, respectively, while 23.2% of in-school adolescents had considered suicide, highlighting an urgent public health crisis [9].

Although the transition from childhood into adolescence is crucial for targeted mental health support, many mental health-related difficulties in this stage of life are often unrecognized and subsequently unsupported [7, 10]. These usually have dire consequences, especially on their health and social functioning in adulthood. Adolescents and young people experiencing mental health conditions face several challenges, including isolation, stigma, discrimination, and difficulty in accessing health services [10-12]. Also, many studies have established a reluctance to seek help among adolescents and young people [12-14].

Help-seeking behaviour is defined as a psychosocial health behaviour that involves disclosing a problem to obtain external support [13]. This is often either a formal or informal entity. Some informal support may come from parents, friends, or religious leaders, while common formal support includes doctors, psychologists, or social workers [13-15]. Despite the high prevalence of depression globally, as few as 10% of young people in need receive psychological support due to significant barriers [16]. In the Nigerian context, these barriers include widespread stigma, lack of mental health literacy, and cultural beliefs attributing mental illness to supernatural causes or "sickness of the brain" [17-19].

Mental health help-seeking behaviour is the process of engaging mental health services when experiencing distress or mental health-related issues [14]. The World Health Organization has recommended integration of mental health in primary health care; however, this is still in progress [14]. The importance of understanding adolescents' and young people's help-seeking behaviours cannot be overstated. Fear, depression, emotional imbalance, isolation, and suicidal thoughts are the results of not seeking mental health help [8, 14].

A study by Barrow and Thomas [20] highlighted important implications for improving adolescents' help-seeking behaviours and increasing mental health support in schools. Stigma and negative beliefs towards mental health services and professionals were the most cited barriers to help-seeking by adolescents in another study [6]. In Nigeria, studies have highlighted the need to focus on the mental health of adolescents by planning preventive programs, creating awareness on mental health-promoting strategies, and introducing child and adolescent

psychiatric health services [8]. A study by Abugu et al among in-school adolescents reveals that students sought help from parents/guardians, doctors, and mental health professionals [14].

Most studies of help-seeking behaviours among adolescents and young people in Nigeria focus primarily on in-school adolescents [9, 14, 17]; there is little literature exploring these behaviours in community settings. This study, therefore, sought to assess the mental health help-seeking behaviours of adolescents and young people in communities in Bauchi State, Nigeria. It aimed to explore whether gender, age, or depression severity had a role to play in help-seeking behaviours with a view to contributing to the broader discourse on the provision of mental health services in community settings.

## Materials and Methods

### Research Design and Study Setting

This study, conducted in Bauchi State, Nigeria, used a cross-sectional baseline survey conducted in May 2026 to assess the mental health help-seeking behaviours of adolescents and young people in a community setting. Bauchi State in the North-East geopolitical zone of Nigeria is multi-ethnic and has a relatively young population, with 47.1% aged 0 to 14 years. Data were collected from adolescents and young people in communities across 9 of the 20 wards of the state capital, Bauchi Local Government Area (LGA).

### Study Population and Eligibility

The study population comprised adolescents and young people aged 15 to 24 years. Participants were recruited from sampled communities in Bauchi Local Government Area. Inclusion criteria required participants to be residents of the community for at least 6 months and to provide either written informed consent (for those aged 18-24) or individual assent alongside parental/guardian consent (for those aged 15-17). Conversely, individuals below 15 years and above 24 years of age, and who had not lived in the community for at least six months, were excluded from the study. Also, participants who did not provide informed consent were excluded from the study.

### Sampling Technique

A multistage sampling technique was employed to select eligible respondents. In the first stage, Bauchi LGA was selected using a purposive, non-random sampling approach—subsequent stages involved selecting wards from the list.

The sample size for this study was calculated using Andrew Fisher's sampling technique $n = z^2pq/d^2$ where 'n' is the required sample size; 'Z' is the standard normal deviation corresponding to the 95% Confidence interval (equivalent to 1.96); 'P' is the prevalence of the attribute being studied and was estimated at 0.5; 'q' is 1- p and 'd' is the margin of error or the desired level of precision which was set at 5% (0.05) [21]. Therefore, a total of 384 participants was calculated as the minimum required sample size, and to account for potential questionnaire loss and non-response to completed questionnaires, an additional 10% of the sample size.

### Data Collection Instruments

Standardized and validated tools were used to ensure data reliability. The questionnaire comprised 3 sections: Section A focused on socio-demographic characteristics of the respondents, including age, gender, education, religion, and household size. Section B was the Patient Health Questionnaire-9 (PHQ-9), used to measure depressive symptoms, with the scores ranging from 0 to 27 [22]. Based on this, a score of 0-4 was graded as "no or minimal depression", 5-9, "mild depression", 10-14, "moderate depression", 15-19, "moderately severe depression", and a score of 0-27 was considered "severe depression". Section C was the General Help-Seeking Questionnaire,

vignette version (GHSQ-V,15) [23, 24], adapted for this context, which assessed the likelihood of seeking help for depression from various formal and informal sources, usually 15 items. The responses from the GHSQ were rated on a 7-point Likert-type scale ranging from Extremely Unlikely = 1, Unlikely = 3, Likely = 5, to Extremely Likely = 7. Quantitative data were collected using Kobo Collect, administered by trained research assistants to minimize data entry errors.

Quantitative data were analyzed using IBM Statistical Product for Services and Solutions (SPSS) version 26 software. Data collected from respondents were reviewed for completeness, cleaned, and recoded as appropriate. The analysis included frequency distributions to determine the prevalence of depression and help-seeking sources, and descriptive statistics (means and standard deviations) for help-seeking behaviours. Independent samples t-tests were used to evaluate differences in mean PHQ-9 scores by gender and age group. Chi-square test was used to determine if there was any association between depression severity and Gender or age group. Independent samples t-test and One-way Analysis of Variance (ANOVA) were used to explore the differences in help-seeking behaviours across the various sources, categorized as informal sources (parents/guardians, siblings/close relatives, close friends/peers, partner/spouse), formal/professional sources (Teacher, School Counsellor, PHC worker/doctor, mental health professional, pharmacist/chemist), community and digital sources (religious leader, traditional leader, online resources/helpdesk/NGO) and Self-reliance, according to gender and age group. The significance level was set to 0.05 for all analyses.

### Reliability and Validity of the Instruments

The PHQ-9 and GHSQ were tested for reliability and validity after pilot testing of the questionnaires. Reliability analysis of the PHQ-9 revealed a Cronbach's Alpha value of 0.719 across the 9 measurement items, indicating an acceptable level of internal consistency among the items. This suggests that the PHQ-9 consistently measures depressive symptoms among adolescents and young people in Bauchi State. Reliability analysis of the GHSQ revealed a Cronbach's alpha of 0.865 across the 15 measurement items, indicating good internal consistency.

Construct validity for the two instruments was examined using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity. The KMO value for the PHQ-9 was 0.615, with Bartlett's Test of Sphericity statistically significant ($X^2 = 790.17, df = 36, p < 0.001$). Conversely, the KMO value for the GHSQ was 0.882, with Bartlett's test of Sphericity statistically significant ($X^2 = 2439.629, df = 105, p < 0.001$). These results confirm that the measurement instruments were both reliable and valid for subsequent statistical analyses.

## Results

### Sociodemographic Characteristics of Respondents

390 adolescents and young people participated in the study. Table 1 shows that the respondent population was evenly distributed between males (50%) and females (50%). About three-fifths (60.5%) of respondents were adolescents aged 15 to 19 years, while the remainder (39.5%) were young people aged 20 to 24 years. The mean age of respondents was $18.84 \pm 2.59$ years. The majority of respondents had a secondary education (66.7%), with only 1.3% reporting never attending school. Similarly, majority of respondents were never married (86.9%). Islam was the dominant religion practiced by the respondents (93.8%). Over a third of the respondents were students, with 24.4% and 22.1% reporting self-employment and farming as their main sources of livelihood. Almost three-quarters of

respondents lived with their parents, followed by 16.7% living with relatives and 7.7% living with their spouses.

## Prevalence of Depression

This cross-sectional survey revealed a high prevalence of mild to severe depression (96.2%) among the study respondents. Overall, the reported prevalence of depression using PHQ-9 was 19.2% mild, 58.7% moderate, 15.6% moderately severe, and 2.6% severe (Table 2). There was no significant difference in reported depression between male and female respondents (p=0.639). However, across age groups, mild and moderate depression were higher among adolescents compared to young people; with moderately severe depression higher among young people compared to adolescents (p=0.016), as seen in Table 3.

**Table 1.** Socio-Demographic Characteristics of Respondents (N=390)

| Variable | Frequency (N) | Percentage (%) |
|---|---|---|
| **Gender** | | |
| Female | 195 | 50.0% |
| Male | 195 | 50.0% |
| **Age Group** | | |
| 15-19 | 236 | 60.5% |
| 20-24 | 154 | 39.5% |
| **Age in years** | | |
| Mean± SD | 18.84± 2.59 | |
| **Education** | | |
| Never attended school | 5 | 1.3% |
| Qu'ranic | 38 | 9.7% |
| Primary | 66 | 16.9% |
| Secondary | 260 | 66.7% |
| Tertiary | 21 | 5.4% |
| **Marital Status** | | |
| Never Married | 339 | 86.9% |
| Married | 38 | 9.7% |
| Divorced/Separated | 12 | 3.1% |
| Widowed | 1 | 0.3% |
| **Religion** | | |
| Islam | 366 | 93.8% |
| Christianity | 24 | 6.2% |
| **Main Livelihood/Occupation** | | |
| None | 50 | 12.8% |
| Farming | 86 | 22.1% |
| Student | 148 | 37.9% |
| Self-employed | 95 | 24.4% |
| Other | 11 | 2.8% |
| **Living Arrangement** | | |
| With parents | 291 | 74.6% |

| | | |
|---|---|---|
| With Spouse | 30 | 7.7% |
| With Relatives | 65 | 16.7% |
| Alone | 3 | .8% |
| Other | 1 | .3% |

The overall mean PHQ-9 score was 11.65±3.6, indicating moderate depression, with female respondents having a higher mean PHQ-9 score (11.9±3.7) than male respondents (11.4±3.4), although this was not significant (Table 2). Table 3 shows that across age groups, however, young people (20-24 years) had a higher mean PHQ-9 score of 12.3±3.6 than adolescents (11.2±3.5; p=0.004).

**Table 2.** Comparison of Depression Severity and Mean PHQ-9 Scores by Gender

| **Variable** | **Male (n= 195)** | **Female (n= 195)** | **Total (n= 390)** | **Test Statistic** | **p-value** |
|---|---|---|---|---|---|
| **Depression Severity (PHQ-9)** | **n (%)** | **n (%)** | **n (%)** | **$\chi 2$ =2.529a** | **.639** |
| Minimal (0–4) | 7(1.8%) | 8(2.1%) | 15(3.8%) | | |
| Mild (5–9) | 43(11.0%) | 32(8.2%) | 75(19.2%) | | |
| Moderate (10–14) | 113(29.0%) | 116(29.7%) | 229(58.7%) | | |
| Moderately Severe (15–19) | 28(7.2%) | 33(8.5%) | 61(15.6%) | | |
| Severe (20–27) | 4(1.0%) | 6(1.5%) | 10 (2.6%) | | |
| **PHQ-9 Mean Score** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **t =-1.193** | **.233** |
| Total Score (0–27) | 11.4 (3.4) | 11.9(3.7) | 11.65 (3.6) | | |

**Table 3.** Comparison of Depression Severity and Mean PHQ-9 Scores by Age Group

| **Variable** | **15-19 years (n= 236)** | **20-24 years (n= 154)** | **Total (n= 390)** | **Test Statistic** | **p-value** |
|---|---|---|---|---|---|
| **Depression Severity (PHQ-9)** | **n (%)** | **n (%)** | **n (%)** | **$\chi 2$ = 12.153a** | **.016** |
| Minimal (0–4) | 12(3.1%) | 3(0.8%) | 15(3.8%) | | |
| Mild (5–9) | 48(12.3%) | 27(6.9%) | 75(19.2%) | | |
| Moderate (10–14) | 145(37.2%) | 84(21.5%) | 229(58.7%) | | |
| Moderately Severe (15–19) | 26(6.7%) | 35(9.0%) | 61(15.6%) | | |
| Severe (20–27) | 5(1.3%) | 5(1.3%) | 10 (2.6%) | | |
| **PHQ-9 Mean Score** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **t =-2.924** | **.004** |
| Total Score (0–27) | 11.2(3.5) | 12.3(3.6) | 11.65 (3.6) | | |

## Help-Seeking Behaviours of Adolescents and Young People in Bauchi State

The General Help-Seeking Questionnaire (GHSQ-V, 15) was used to assess respondents' help-seeking behaviours. Descriptive results from the GHSQ are presented in Figure 1. The 7-point Likert was collapsed into a 3-point Likert where responses of 'Extremely unlikely', 'Slightly unlikely' and 'Unlikely' were grouped as 'Unlikely', and all 'Extremely likely', 'Slightly likely' and 'Likely' were grouped as 'Likely'. The majority of respondents indicated they would likely receive help from informal sources, such as a parent or guardian (94%), followed by a sibling or close relative (89%) and a religious leader (85%).

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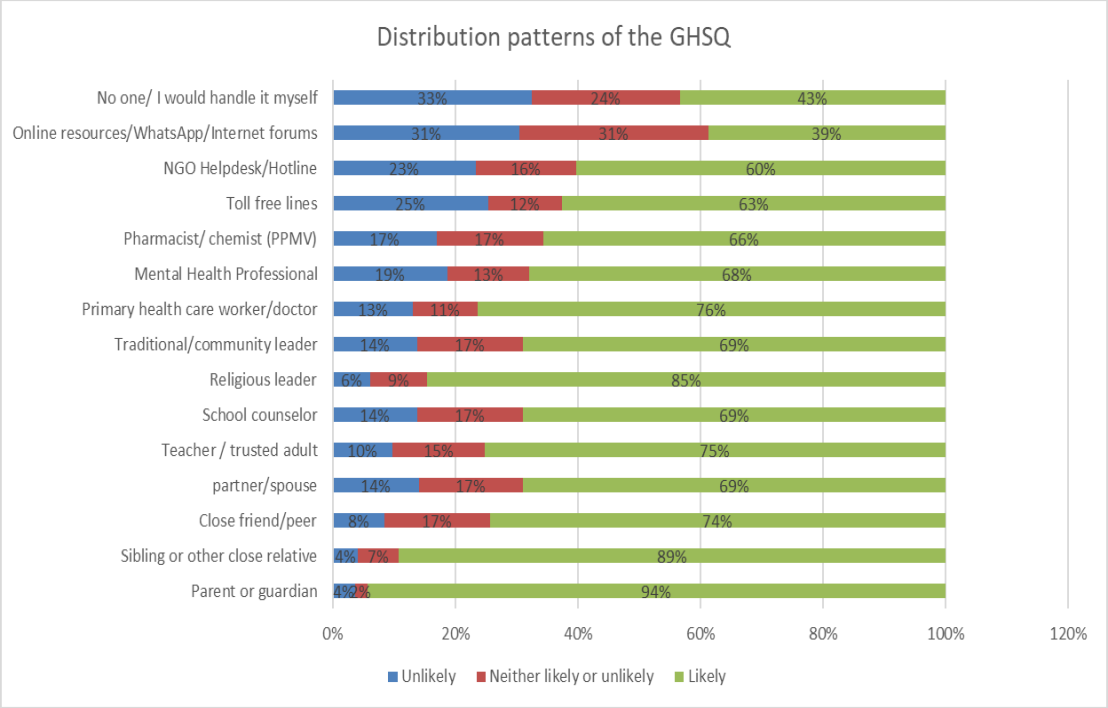


**Figure 1.** Help-Seeking Behaviours of Adolescents and Young People in Bauchi State, Nigeria (n=390)

Table 4 presents the mean help-seeking scores across the help-seeking sources in this study. The mean scores further buttress that adolescents and young people in Bauchi State sought help from their parents/guardians ($\bar{x}$=5.58, SD=1.076), siblings/close relatives ($\bar{x}$=5.31, SD=0.940), religious leaders ($\bar{x}$=5.28, SD=1.160), and close friends ($\bar{x}$=5.01, SD=1.123) as seen in Table 4.

**Table 4.** Mean Analysis of Mental Health Help-Seeking Behaviors of Adolescents and Young People in Bauchi State, Nigeria (n=390)

| **Help-Seeking Source (GHSQ)** | **Mean($\bar{x}$)** | **Standard Deviation** |
|---|---|---|
| Parent or Guardian | 5.58 | 1.076 |
| Sibling or Relative | 5.31 | 0.940 |
| Close friend/peer | 5.01 | 1.123 |
| Partner/Spouse | 4.82 | 1.248 |
| PHC worker/doctor | 4.91 | 1.034 |
| Mental health professional | 4.70 | 1.149 |
| Teacher | 4.86 | 1.034 |
| School Counsellor | 4.84 | 1.109 |
| Pharmacist/chemist | 4.73 | 1.125 |
| Religious leader | 5.28 | 1.160 |
| Traditional/community leader | 4.70 | 1.148 |
| Online resources/ WhatsApp/internet | 4.09 | 1.225 |
| Toll-free lines | 4.44 | 1.167 |
| No one/Handle myself | 4.02 | 1.405 |
| **Total Mean Score** | **4.78** | **0.675** |

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Table 5 below shows the mean analysis of help-seeking behaviour across various sources, categorized by age group. More adolescents sought help from their parents/guardians ($\bar{x}$=5.62, SD=1.079), siblings/close relatives ($\bar{x}$=5.35, SD=0.940), partner/spouse ($\bar{x}$=4.86, SD=1.241), Primary Health Care(PHC) worker/doctor ($\bar{x}$=4.95, SD=0.924), mental health professional ($\bar{x}$=4.74, SD=1.030), pharmacist/chemist ($\bar{x}$=4.79, SD=1.029) and toll free lines ($\bar{x}$=4.48, SD=1.124) than young people ($\bar{x}$=5.53, SD=1.074, $\bar{x}$=5.26, SD=0.941; $\bar{x}$=4.75, SD=1.259; $\bar{x}$=4.84, SD=1.183; $\bar{x}$=4.64, SD=1.313; $\bar{x}$=4.64, SD=1.256, $\bar{x}$=4.34, SD=1.117) respectively. However, young people would not seek help ($\bar{x}$=4.18, SD=1.331) as often as adolescents ($\bar{x}$=3.91, SD=1.444, p=0.059). There was no significant difference in help-seeking behaviours among adolescents and young people (F=0.246, p=0.620).

**Table 5.** ANOVA Analysis of Mental Health Help-Seeking Behaviors of Adolescents and Young People by Age Group in Bauchi State, Nigeria (n=390)

| **Help-Seeking Source (GHSQ)** | **15–19 years (n=236) Mean (SD)** | **20–24 years (n=154) Mean (SD)** | **F-statistic** | **p-value** |
|---|---|---|---|---|
| **Informal Sources** | | | .314 | .576 |
| Parent or Guardian | 5.62 (1.079) | 5.53(1.074) | .755 | .385 |
| Sibling or Relative | 5.35(0.940) | 5.26(0.941) | .811 | .368 |
| Close friend/peer | 4.97(1.087) | 5.07(1.178) | .819 | .366 |
| Partner/Spouse | 4.86(1.241) | 4.75(1.259) | .739 | .390 |
| **Formal/Professional Sources** | | | .599 | .439 |
| PHC worker/doctor | 4.95(0.924) | 4.84(1.183) | 1.040 | .308 |
| Mental health professional | 4.74(1.030) | 4.64(1.313) | .780 | .378 |
| Teacher | 4.93(0.967) | 4.75(1.123) | 2.876 | .091 |
| School Counsellor | 4.79(1.086) | 4.92(1.143) | 1.230 | .268 |
| Pharmacist/chemist | 4.79(1.029) | 4.64(1.256) | 1.649 | .200 |
| **Digital & Community Sources** | | | .142 | .706 |
| Religious leader | 5.27(1.204) | 5.31(1.093) | .080 | .778 |
| Traditional/community leader | 4.66(1.094) | 4.76(1.226) | .750 | .387 |
| Online resources/ WhatsApp/internet | 4.11(1.226) | 4.34(1.117) | 1.957 | .163 |
| Toll-free lines | 4.48(1.124) | 4.37(1.231) | .872 | .351 |
| **Self-Reliance** | | | | |
| No one/Handle myself | 3.91(1.444) | 4.18 (1.331) | 3.595 | .059 |
| Total Mean Score | 4.80(0.656) | 4.76(0.705) | 0.246 | .620 |

Table 6 shows that more females sought help from their close friends/peers ($\bar{x}$ =5.10, SD=1.117), PHC worker/doctor ($\bar{x}$=4.98, SD=0.914), mental health professional ($\bar{x}$=4.73, SD=1.135), pharmacist/chemist ($\bar{x}$=4.81, SD=1.094), online resources ($\bar{x}$=4.23, SD=1.272) and toll free lines ($\bar{x}$=4.59, SD=1.145) compared to males (x=4.91, SD=1.125; $\bar{x}$=4.84, SD=1.140; 4.67, SD=1.165; $\bar{x}$=4.66, SD=1.153; $\bar{x}$=3.96, SD=1.161; $\bar{x}$=4.34, SD=1.183). Overall, there was no significant difference in help-seeking behaviours by gender (t=-0.370, p=0.712); however, more females sought help from online resources than males (t=-2.202, p=0.028). Interestingly, males would not seek help ($\bar{x}$=4.16, SD=1.302) as often as females ($\bar{x}$=3.87, SD=1.490; t=2.099, p=0.036).

**Table 6.** Mean Analysis of Mental Health Help-Seeking Behaviors of Adolescents and Young People by Gender in Bauchi State, Nigeria (n=390)

| Help-Seeking Source (GHSQ) | Male (n=195) Mean (SD) | Female (n=195) Mean (SD) | t-statistic | p-value |
|---|---|---|---|---|
| **Informal Sources** | | | | |
| Parent or Guardian | 5.59(1.082) | 5.57(1.074) | 0.188 | .851 |
| Sibling or Relative | 5.35(0.948) | 5.28(0.933) | 0.754 | .452 |
| Close friend/peer | 4.91(1.125) | 5.10(1.117) | -1.672 | .095 |
| Partner/Spouse | 4.82(1.261) | 4.82(1.237) | 0.000 | 1.000 |
| **Formal/Professional Sources** | | | | |
| PHC worker/doctor | 4.84(1.140) | 4.98(0.914) | -1.324 | .186 |
| Mental health professional | 4.67(1.165) | 4.73(1.135) | -.572 | .567 |
| Teacher | 4.93(0.961) | 4.78(1.101) | 1.373 | .171 |
| School Counsellor | 4.84(1.100) | 4.84(1.122) | -0.046 | .964 |
| Pharmacist/chemist | 4.66(1.153) | 4.81(1.094) | -1.352 | .177 |
| **Digital & Community Sources** | | | | |
| Religious leader | 5.35(1.185) | 5.22(1.134) | 1.092 | .276 |
| Traditional/community leader | 4.79(1.055) | 4.60(1.229) | 1.681 | .094 |
| Online resources/ WhatsApp/internet | 3.96(1.161) | 4.23(1.272) | -2.202 | .028 |
| Toll-free lines | 4.34(1.183) | 4.59(1.145) | -1.696 | .091 |
| **Self-Reliance** | | | | |
| No one/Handle myself | 4.16(1.302) | 3.87(1.490) | 2.099 | .036 |
| Total Mean Score | 4.77(0.723) | 4.80(0.624) | -0.370 | .712 |

## Difference between Depression Severity Groups on Help-Seeking Behaviour among Adolescents and Young People in Bauchi State, Nigeria

Table 7 presents an analysis of variance comparing help-seeking behaviours (Total Help-Seeking mean score) across levels of depression severity among respondents (N=390, df total=389). Overall, there was an observable trend showing a decrease in help-seeking behaviours with increasing depression severity. Respondents with no/minimal depression had the highest mean help-seeking score ($\bar{x}$=5.07, SD=0.652), while those with severe depression had the lowest mean help-seeking score ($\bar{x}$=4.25, SD=0.585). Respondents in the 'moderate' and 'moderately severe' categories reported identical mean scores ($\bar{x}$ =4.78). However, the difference between depression severity groups on help-seeking behaviours was found not to be statistically significant (F=2.283, p=0.060). This indicates that, for this sample, depression severity alone was not an indicator of help-seeking behavior.

**Table 7.** Difference between Depression Severity Groups on Help-Seeking Behaviours among adolescents and young people in Bauchi State

| Depression Group | Mean | SD | GHS Score | Sum of Squares | df | MS | F | Sig. |
|---|---|---|---|---|---|---|---|---|
| No/Minimal (0-4) | 5.07 | .652 | Between Groups | 4.104 | 4 | 1.026 | 2.283 | .060 |
| Mild (5-9) | 4.81 | .710 | Within Groups | 173.008 | 385 | .449 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Moderate (10-14) | 4.78 | .666 | **Total** | **177.113** | **389** | | | |
| Moderately Severe (15-19) | 4.78 | .653 | | | | | | |
| Severe (20-27) | 4.25 | .585 | | | | | | |
| **Total** | **4.78** | **.675** | | | | | | |

## Discussion

The main purpose of this cross-sectional study was to examine the mental health help-seeking behaviours among adolescents and young people (15 to 24 years) in Bauchi State, Nigeria. In addition, this study sought to explore whether gender, age, or depression severity had a role to play in help-seeking behaviours among this demographic. The most striking finding of this study is the high prevalence of depressive symptoms, with 19.2% mild, 58.7% moderate, 15.6% moderately severe, and 2.6% severely depressed. This is significantly higher than the 10%-37% range previously estimated for Nigerian adolescents [8, 9]. The discrepancies in depression prevalence might be due to the methodological differences in data collection, as well as the perception of depression in the various settings. The overall mean PHQ-9 score of 11.65 indicates a moderate level of depression within the community, and is consistent with a similar study among adolescents [25].

Interestingly, while there was no significant difference in depression prevalence between genders (p=0.639), age was a significant factor. Young people (20 to 24 years) exhibited higher mean depression scores (12.3±3.6) compared to adolescents (11.2±3.5, p=0.004). This suggests that as individuals transition into young adulthood, they may face increased stressors that exacerbate mental health challenges in this setting, as seen in other reports [26].

The data reveal a strong preference for informal help-seeking sources, as also reported by similar studies [12, 14]. Respondents in this study reported being most likely to seek help from a parent or guardian (94%), followed by siblings/relatives (89%) and religious leaders (85%). This reliance on informal networks is consistent with cultural norms in Northern Nigeria, where religious and family structures are the primary support systems. Mental health interventions may target these sources for effective reach in these settings. Also, adolescents and young people are likely to seek help from those they are most familiar with and feel safe with. This study, however, did not find any overall difference in help-seeking behaviours between male and female respondents.

Interestingly, this study found that female respondents were significantly more likely to seek help from online sources than their male counterparts. Previous studies [6, 14, 15] have found that younger women are particularly likely to be influenced by peers and social media, and that internet access facilitates help-seeking among women. This may also be influenced by the cultural setting in Northern Nigeria, and with increased access to phones, seeking help online may be easier.

This study also revealed that more males would not seek help compared with their female counterparts, but would instead handle it themselves. This clearly aligns with recent studies [12, 14] where poor help-seeking was more pronounced in males due to gender stereotypes and the perceived desire not to be seen as ‘weak’ or ‘emasculated’ by their counterparts. This high level of self-reliance represents a major barrier to the early identification and treatment of depression; mental health interventions should target males who may likely not want to seek help.

Finally, although this study found that help-seeking tended to decrease with increasing

depression severity, this was not found to be statistically significant. However, other studies have established that higher levels of psychological distress, suicidal ideation, and depressive symptoms are consistently linked to lower help-seeking behaviors [6, 13].

## Conclusion

This study highlights a critical public health crisis among adolescents and young people in Bauchi State, characterized by a high burden of moderate to severe depression. Young people exhibited higher mean depression scores compared to adolescents. Generally, respondents were more comfortable with informal help-seeking sources, including parents/guardians, siblings/relatives, and religious leaders. Females were more likely to seek help from online sources compared to their male counterparts, while male respondents were less likely to seek help. Although help-seeking was found to decrease with increasing depression severity, it was not significant in this study.

Further research may explore the sensitivity of the PHQ-9 in the identification of depression in community settings in Nigeria. Mental health interventions in Nigeria should be decentralized into community and religious structures, while policy efforts should improve community-level identification of depression and strengthen referral pathways for specialized care. In addition, investments should be made in user-friendly, easily accessible online resources for adolescents and young people, while specific programs should be designed to promote positive help-seeking behaviors among male adolescents and young people.

## Conflict of Interest

The authors declare no conflict of interest.

## Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. All costs to conduct this research were borne by the corresponding author.

## Ethical Approval

The study was conducted in accordance with the most stringent ethical standards to guarantee the respect, dignity, and protection of all participants. In accordance with the Universal Declaration of Human Rights, the International Code of Medical Ethics, and the WHO Ethical Guidelines for Health Research, ethical approval was obtained from the Bauchi State Health Research Ethics Committee (Ref. No.: NHREC/TR/BAU-HREC/28/8/2023). The purpose, procedures, potential hazards, and benefits of the study were fully disclosed to all participants. Informed assent and informed consent were obtained from minor and adult participants, respectively. Respondents were guaranteed the right to withdraw at any time without penalty, and participation was entirely voluntary. Anonymity and confidentiality were rigorously upheld. All identifiable data was eliminated from the records and substituted with codes. As data was collected using Kobo Collect, all electronic data was password-protected. The investigation refrained from employing any form of coercion, deception, or undue influence. Data security and integrity were prioritized throughout the research process.

## Data Availability

The datasets generated and analyzed during the study are available from the corresponding author upon reasonable request.

## Author Contributions

Comfort Runyi Oyom Effiom conceptualized and designed the study, funded the research, conducted the research, performed data analysis, and wrote the manuscript. Shehu Isah coordinated fieldwork and analyzed the data. Helen Idiong edited and proofread the manuscript. Amitabye Luximon-Ramma reviewed the manuscript and provided technical mentorship. Olugbenga Asaolu reviewed and

edited the manuscript and supervised the entire research. All authors read and approved the final manuscript.

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# Beyond Attendance: Drivers of Delayed and Discontinued Antenatal Care in Karisimbi Health Zone, Eastern DRC; a Triangulated Qualitative Study

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***Abstract*** *In unstable urban environments such as Karisimbi in the eastern of the Democratic Republic of Congo (DRC), timely access and completion of antenatal care (ANC) remains challenging. To explore how women, community leaders, and health providers in Karisimbi Health Zone understand the delayed and incomplete ANC use. We conducted a triangulated qualitative study. 64 participants were purposively enrolled: 51 women delivered in the previous 12 months, 7 healthcare providers, 5 religious leaders, and 1 community leader. Data was collected through focal group discussion and in-depth interviews in Swahili and French depending on the preference of the participants. Data was recording, transcribed, translated in English and imported in Nvivo15 for thematic framework analysis and triangulation. Six themes were identified: ANC as a valued but not always urgent service, cumulative cost of seeking care, livelihood and waiting time, social judgment, service experience, and household and community support. Delayed and incomplete ANC use was shaped by interacting with financial, social, and health-system constraints, including care-related costs and income loss; low perceived need without symptoms; fear of social judgment, provider reception, and trust; and limited household or community support. Improving uptake requires integrated action on affordability, quality of care, trust, and community support.*

***Keywords*** *Antenatal Care, Community Support, Democratic Republic of the Congo, Qualitative Research.*

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## Introduction

Antenatal care has become a central platform for maternal and newborn health because it combines clinical assessment, disease prevention, counselling, risk detection and linkage to facility-based delivery. Contemporary antenatal care (ANC) debates have moved beyond whether a woman has at least one contact with the health system. Increasing attention is now given to when care begins, whether it continues, what content is received, and whether women experience care as respectful and useful [1, 2]. This shift is especially important in settings where health facilities exist but access remains mediated by cost, insecurity, social norms, gender relations and variable service readiness[3, 4].

Globally, maternal mortality fell by 40% over the period 2000-2023, but although progress has been made in some regions, mothers in Sub-Saharan Africa still face great challenges [5]. Persistent inequalities in access to quality health care, lack of trained health personnel, and health system inequalities still threaten lives during a time that should be filled with joy and hope [6–9].

In the Democratic republic of Congo (DRC), a community-based mother and child health intervention drawing on the three delays model increased the odds of four or more antenatal care visits at the intervention site, suggesting that community health interventions adapted to the local context may enhance antenatal care utilization [10]. Four studies indicate that the optimal approach is not a singular intervention but rather an integrated strategy that encompasses demand-side support, affordability, service quality, respectful care, partner and community engagement, and health system enhancement. However, existing approaches have important limitations; surveys often leave unexplained the everyday calculations through which women decide whether to attend now, attend later, or stop attending [10–13]. In eastern DRC, the precarious health system overlaps with insecurity, mobility, informal urban livelihoods, and economic fragility of households [14], meaning that geographical proximity to a facility may not translate into effective access. Qualitative inquiry is therefore needed to understand how biomedical recommendations are interpreted within household economies, informal labor, social expectations and lived experience of health services in this setting.

This study focuses on Karisimbi Health Zone in North Kivu Province. Its objective is to explore how women, community leader, religious leaders, health providers explain delayed ANC initiation and discontinuation, and to identify the mechanisms linking economic constraints, social norms, household relations and service experience to women's ANC trajectories. The novelty of this work lies in its triangulated qualitative design in a fragile urban health-zone setting of eastern DRC, integrating women lived experience with community and provider perspectives to move beyond attendance counts toward an explanation of how ANC use is negotiated in everyday life.

This study is guided by an adapted socio-ecological, patient-centered access framework. It views antenatal care (ANC) use in Karisimbi not as a choice, but as a pathway shaped by women's capacity to recognize when care is needed, seek support, access health services, afford treatment, and maintain communication with healthcare providers is essential to timely and effective maternal care [1, 15]. At individual and household levels, delayed initiation or discontinuation will be explored through pregnancy recognition, perceived risk, knowledge, partner support, control over money, transport and competing domestic or survival priorities [15, 16]. At community level, the framework examines how gender expectations, religious advice, stigma and norms around pregnancy disclosure influence acceptance of ANC care [15]. At service level, it focuses on affordability, availability, respectful communication, waiting

time, confidentiality and perceived quality, consistent with world health organization (WHO)'s emphasis on positive pregnancy experience [1, 17]. Bringing together the perspectives of women, community leaders and health-care providers strengthened the analysis and helped identify what drives or interrupts ANC use [18].

## Materials and Methods

### Study Design

We used a qualitative interpretive design with triangulation across participant groups. It sought to provide a reason behind meanings, constraints and mechanisms shaping ANC trajectories in Karisimbi health zone.

### Study Setting

The study was conducted in Karisimbi Health Zone, North Kivu Province, eastern DRC. Karisimbi is an urban and peri-urban setting with 20 health areas and a mix of public, private and faith-linked health facilities. It is characterized by dense urban neighborhoods, informal income-generating activities, reliance on daily cash flow, and uneven community-facility linkages [14, 19, 20].

### Sampling and Participants

Participants were selected through maximum variation sampling including age, employment status, religion and education level. Women were recruited from the community and eligible if they had delivered within the previous 12 months to reduce recall bias and get participant who went through ANC journey in their previous pregnancy. Providers were recruited from ANC service delivery points at health facilities, while religious and community leaders were identified through their recognized roles in community communication and social influence.

The study included 64 participants: 39 women in individual interviews, 12 women in two focus group discussions (six per group), 5 religious leader,1community leaders, and seven health-care providers "Table 1". The sample size was based on saturation of information.

**Table 1.** Study Participants in Karisimbi Health Zone

| Participants | Setting | Category of involvement | FGD | IDI | Number of participants |
|---|---|---|---|---|---|
| Women who delivered within the previous 12 months | Community | Women with recent ANC experience | 12(six per group) | 39 | 51[a] |
| Religious/community leaders | Community | Community and religious influence on ANC norms and referrals | - | 6 | 6 |
| Health-care provider | Health facility | Facility readiness and service delivery constraints | - | 7 | 7 |
| Total sample | | | 2 FGDs | 52 IDIs | 64 |

[a] *the 51 women include 39 women interviewed individually and 12 women who participated in two focus group discussions. ANC, antenatal care; FGD, focus group discussion; IDI, in-depth interview.*

## Data Collection

Before data collection, the principal investigator recruited five interviewers:4 female and 1 man to comply with gender norm in local community. He trained them for two days on the study objectives, qualitative interviewing, focus group facilitation, informed consent, probing, audio-recording, field-note taking, and confidentiality. Written informed consent was received from all participants.

Data were gathered using semi-structured interview and focus group discussion guides tailored to three participant groups: women, health-care providers, religious and community leaders. The guides included common core questions to enable triangulation, while allowing each group to discuss issues specific to their role and experience. The tools were piloted with three eligible women and reviewed with the interviewers to assess clarity, flow, language, cultural appropriateness, and duration. Minor revisions were made to wording, sequencing, and probes before formal data collection.

Women's interviews and focus groups explored perceptions of antenatal care, timing of first attendance, reasons for delayed initiation or discontinuation, household decision-making, financial and transport barriers, service experience, and suggestions for improvement. Provider and manager interviews examined ANC attendance patterns, service readiness, stock-outs, user fees, workload, and community-facility collaboration. Interviews with religious and community leaders focused on pregnancy-related norms, communication channels, referral practices, and their role in promoting ANC.

Two focus group discussions were conducted with six women each and lasted approximately 90 minutes. Individual interviews with women lasted about 30 minutes. Interviews and discussions were conducted in French or Kiswahili, according to participant preference. Participants were encouraged to speak freely, and probes were used to deepen responses and maintain consistency across interviews. With consent, audio recordings were made of all interviews and discussions, and field notes were taken.

Data quality was strengthened through close supervision by the principal investigator, regular review of recordings, transcripts, and field notes, and collective debriefings to deal with new concerns and synchronize data collection among participant groups. Transcription and translation were checked for consistency, with particular attention to preserving the meaning of key terms related to ANC, costs, shame, trust, community and household support.

Trustworthiness was strengthened through following approaches: Confirmability was supported by retaining recordings, field notes, transcripts and coding decisions to keep findings grounded in participants meaning considering Karisimbi context. Transferability was enhanced by clearly describing the Karisimbi context, participants and data collection procedures. Dependability was promoted through interviewer training, piloting, semi-structured guides, supervision, transcript checks and team debriefings. Reflexivity was anticipated in choice of interviewers and discussion during briefing and debriefing in pilot phase by discussing how their community profile, assumptions and interaction with women, leaders and health providers influence questioning and interpretation. Triangulation was achieved by comparing perspectives from women, providers and religious/community leaders, and by combining interviews with focus group discussions.

## Data Control and Analysis

All interviews and focus group discussion were transcribed in French using kobo collect and then translated in English by an expert and validate by the principal investigator before

importation in Nvivo 15. Analysis employed a thematic approach. First, deductive domains were developed from the interview guides and the broader literature on ANC utilization, including perceived value of ANC, cost, distance, household influence, community engagement, service readiness and quality of care. Second, inductive coding refined these categories through repeated reading of transcript summaries, illustrative quotations and matrices. Coding focused on units of meaning rather than isolated words. Codes were then grouped into analytic themes and compared across participant categories.

Triangulation was undertaken at three levels. Initial triangulation examined codes from women, focus groups, community leaders, religious leaders, and providers. Thematic triangulation examined whether codes clustered similarly across participant groups. Interpretive triangulation identified convergence, complementarity and divergence.

## Results

### Participants Presentation and Interpretative Thematic Analysis

A total of 64 participants were included:39 women in individual in-depth interviews, 12 women in two focus group discussions, 5 religious leaders, 1community leader, and 7 health-care providers. Most participants were female (81.3%). The age distribution was broad, with the largest groups aged 25-29 years (23.4%), 30-34 years (20.3%), and 35-39 years (17.2%). Educational attainment varied: 35.9% had secondary education, 28.1% primary education, 18.8% no formal education, and 17.2% higher education. Informal income-generating activities were the most common occupation or role (39.1%), followed by household or informal domestic work (26.6%). Religious affiliation was mainly Protestant (40.6%) and Catholic (32.8%), with smaller Muslim and other Christian groups (Table 2).

**Table 2.** Socio-Demographic Characteristics of Study Participants in Karisimbi Health Zone

| Category | Frequency | Per cent |
|---|---|---|
| **Age group** | | |
| 18-24 | 10 | 15.6 |
| 25-29 | 15 | 23.4 |
| 30-34 | 13 | 20.3 |
| 35-39 | 11 | 17.2 |
| 40-44 | 8 | 12.5 |
| >45 | 7 | 10.9 |
| **Sex** | | |
| Female | 52 | 81.3 |
| Male | 12 | 18.8 |
| **Participant group** | | |
| Women interviewed individually | 39 | 60.9 |
| Women participating in focus group discussions | 12 | 18.8 |
| Religious/community leaders | 6 | 9.4 |
| Health-care providers | 7 | 10.9 |
| **Educational level** | | |
| None | 12 | 18.8 |

| | | |
|---|---|---|
| Primary | 18 | 28.1 |
| Secondary | 23 | 35.9 |
| Higher | 11 | 17.2 |
| **Occupation / role** | | |
| Housewife / informal household work | 17 | 26.6 |
| Informal income-generating activity | 25 | 39.1 |
| Formal employment | 9 | 14.1 |
| Health-care provider | 6 | 9.4 |
| Health manager | 1 | 1.6 |
| Religious leader | 5 | 7.8 |
| Community leader | 1 | 1.6 |
| Other | 0 | 0.0 |
| **Religion** | | |
| Catholic | 21 | 32.8 |
| Protestant | 26 | 40.6 |
| Muslim | 7 | 10.9 |
| Other Christian denomination | 7 | 10.9 |
| Other | 3 | 4.7 |

***Note:*** *Percentages were calculated using the total sample size of 64 participants as the denominator.*

The analysis identified six interrelated themes explaining delayed initiation and discontinuation of antenatal care.

## ANC was Valued, but Perceived Value did not Automatically Translate into Early Initiation

Across participant groups, ANC was valued as pregnancy care. Women associated ANC with checking the baby's condition, monitoring fetal position, identifying complications, receiving medicines, and preparing for delivery.

Providers similarly framed ANC as a space for risk detection, health education, prevention, and timely management of complications.

Religious and community leaders also recognized ANC as useful, although they described their involvement in ANC promotion as limited.

However, some women showed that perceived value did not always create a sense of urgency for instance when pregnancy was experienced as normal, they delayed the first visit. For multiparous women, previous uncomplicated pregnancies sometimes reinforced confidence and reduced the perceived need for early attendance.

*"So, at three months, I started ANC to look after my health and that of my child."*

*Woman, 22 years, IDI*

*"ANC helps us support pregnant women, identify risks that may arise during childbirth, and manage them appropriately."*

*Health-care provider, 42 years, KII*

*"I recognize that antenatal care is useful, but we are less involved. If health services share messages with us, we will pass them on."*

*Religious leader, 45 years, KII*

## Costs were Experienced as a Pathway Burden, not a Single Fee

Economic constraint was one of the most consistent explanations for delayed or

discontinued ANC. Women described costs related to consultation cards, laboratory tests, ultrasound, medicines, transport, and purchases outside the facility when supplies were unavailable.

Providers converged with women's point of view by identifying poverty and lack of financial means as major barriers to timely and continuous care.

The divergence lay in the level of detail. Providers often named poverty as a broad determinant, while women described how costs accumulated along the entire care pathway. Attending to ANC required cash before leaving home transport to the facility, payments at the facility, possible external purchases, food during long waits, and income lost from missing daily work. Cost therefore shaped not only whether ANC was valued, but whether attendance was feasible on a given day.

*"Most women are engaged in small-scale street trading; they wake up very early and return home in the evening, looking for ways to support their families, sometimes overlooking other priority needs, including antenatal care appointments."*

*Woman, 35 years, FGD*

## Livelihoods and Waiting Time Made ANC Attendance Economically Risky

Daily livelihood demands shaped both ANC initiation and continuity. Many women relied on informal work or daily income-generating activities. In this context, a long ANC visit could mean losing income needed for food, transport, or household needs. Waiting time was therefore not only an inconvenience; it was an economic and caregiving problem.

Women highlighted the immediate consequences of spending many hours at a facility.

Providers also recognized transport and poverty as barriers, but they less often described how facility waiting time interacted with women's daily life.

*"many women lack transport means to reach the health facility…"*

*Health-care provider, 36 years, KII*

*"I may spend the whole day at the hospital and fail to go out to look for food for my children."*

*Woman, 28 years, IDI*

## Pregnancy Visibility, Shame, and Fear Delayed the First Visit

Several women linked late ANC initiation to shame, fear, or social judgement. Some described fear of injections, while others mentioned lack of appropriate clothing, wanting to hide the pregnancy, or avoiding comments about repeated pregnancies. These concerns were less visible in provider narratives, which focused mainly on poverty, transport, education, and multiparity.

For some women, postponing ANC was a way to control when pregnancy became publicly known.

*"It depends on one person to another: the cost of the card, needing a new dress to go to ANC; for others, it is shame."*

*Woman, 25 years IDI,*

*"I started ANC at seven months; the delay was because I was afraid of the injection."*

*Woman, 18 years, IDI*

## Quality of Reception and Service Readiness shaped Confidence in Continuing Care

Continuity after the first ANC visit was strongly influenced by how women experienced care. Some participants emphasized respectful reception, clear explanations, dignity, and satisfaction. Whereas others mentioned long waits, poor communication, lack of confidence in providers, incomplete examinations, discomfort, and occasional stock-outs.

Providers converged with women by acknowledging that lack of trust and limited materials could reduce attendance.

Conversely, unclear fees, stock-outs, external purchases, poor reception, or perceived neglect weakened confidence in continued care. Service readiness was therefore experienced not only as a technical condition, but also as evidence of whether the facility could meet women's needs.

*"I was welcomed; they treated me with dignity and respect. I was truly satisfied with the services offered by the centre."*

*Woman,38 years IDI*

*"Lack of trust in providers."*

*Health-care provider/manager,47 years KII*

*"Make the necessary materials for ANC available and strengthen awareness-raising."*

*Health-care provider, 33 years KII*

## Household and Community Support Influenced Both Initiation and Continuity

Household support, particularly from husbands or partners, shaped decision-making, money for care, transport, and reminders. Some women described ANC decisions as personal, while others presented them as negotiated within the household. Community structures, including religious leaders, community health workers and women's groups, were also described as potential sources of encouragement and referral.

However, community support was uneven. Religious and community leaders recognized that they could help share ANC messages, and providers acknowledged the potential role of community health workers. Yet participants also described weak or inconsistent links between facilities and community actors.

*"She informed her husband, and afterwards they did the pregnancy test."*

*Woman,23years IDI*

*"Community health workers can take the initiative to spread the message for prevention."*

*Woman, 40 years, IDI*

*"In our Centre, community health workers are not involved in awareness-raising."*

*Health-care provider,27 years KII*

## Cross-Theme Analytic Synthesis

There was the strongest convergence around the practical and social conditions that frame ANC use: cost of care, need for better information and sensitisation, role of community and religious actors and importance of support from partners and families.

However, there were some differences in how participant groups explained delayed ANC use. Women's opinions were much more oriented on everyday experience. They described the cumulative burden of paying for transport, tests, medicines, or other required items, while also losing time and income when they spent long hours waiting at the facility. Their narratives also forward more personal and socially sensitive barriers, including shame, fear, pregnancy denial, poor reception, and concerns about being judged. Health-care providers, in contrast, were more keen to explain delays through structural and service-related factors such as poverty, distance, transport difficulties, low education, high parity, stock-outs, shortages of materials, financing gaps, and lack of items in facilities. Religious and community leaders often stated the issue as one of poverty, lack of awareness, religious and community communication, and weak collaboration with health services.

## Discussion

This study shows that delayed initiation and discontinuation of ANC in Karisimbi are not adequately explained by lack of awareness. Women, providers and community actors recognized the value of ANC, yet timely and sustained use depended on whether care was economically feasible, socially acceptable and trusted. This interpretation is consistent with evidence from sub-Saharan Africa showing that timely and

adequate ANC remain low and are shaped by poverty, education, parity, autonomy, insurance and community context [12, 21]. The findings extend this literature by showing how structural barriers are lived as cumulative pathway costs rather than single fees. Transport, user payments, ultrasound or laboratory costs, childcare, lost market time and long waiting transformed ANC into an economic risk for women dependent on daily livelihoods. These results align with systematic evidence that socioeconomic position, distance and service costs influence ANC utilization, and with qualitative evidence from Somaliland showing that economic barriers, transport, waiting time and provider behavior shape ANC use [3, 22].

A second contribution is the visibility of social and affective barriers. Shame, fear of injections, pregnancy concealment and fear of judgement were prominent in women's accounts but less visible in provider explanations. This suggests the delay on initiation of ANC is also a matter of dignity, privacy and social exposure, not only information or distance. Respectful, person-centered care is therefore central because women's willingness to return depends on whether services produce trust through clear communication, respectful reception, privacy and reliable content [10].

Continuity was also influenced by the availability of service. Women interpreted stock-outs, incomplete examinations and poor reception as signs that returning might not be worthwhile, while providers highlighted shortages, financing gaps and materials. This supports evidence that ANC contact does not guarantee quality; multicountries analyses show substantial gaps in quality-adjusted ANC in sub-Saharan Africa [11].

Finally, household and community support operated as an enabling environment rather than a uniform intervention. Community health workers, husbands, community health workers, women's groups and religious leaders could facilitate money,
information, accompaniment and referral, but their engagement was uneven. Evidence from DRC shows community-based maternal and child health interventions can increase ANC utilization, while reviews indicate that male involvement can improve maternal health service use, though effects depend on how support is defined and implemented [10, 23].

Overall, ANC use in Karisimbi should be understood as a negotiated care trajectory shaped by intersecting economic, social and health-system conditions.

## Strengths, Limitations and Future Research

This study is strengthened by its diverse qualitative sample, including women, focus group participants, community/religious leaders and health-care providers. This triangulated design allowed women lived experiences to be compared with community and facility perspectives, improving credibility and analytic depth. The use of purposive sampling, a structured codebook, thematic matrices and illustrative quotations also supported transparency and dependability.

The study has limitations. It was conducted in one health zone, so findings are not statistically generalizable, although they may be transferable to similar fragile urban settings. Women were interviewed after delivery, which may introduce recall bias, but restricting inclusion to women who had delivered within the previous 12 months reduced this risk. The study did not include adolescent mothers aged 15-17 years or displaced women, whose ANC experiences may differ because of stigma, dependency, mobility, insecurity and disrupted social support [24-26]. It also did not include direct facility observation or quantitative measurement of waiting time, fees, transport costs, stock-outs or readiness; these

constraints are therefore based on participant experience.

Future studies should include adolescent mothers, displaced women and host-community women living alongside displaced populations. However, in humanitarian settings, host communities are sometimes less visible than internally displaced populations, although they may face similar pressure on livelihoods, services and social support [27, 28], therefore the added value of this manuscript is that it foregrounds host community women's everyday negotiations around ANC in a fragile urban health zone, showing that delayed or discontinued care is not simply a knowledge problem but the result of interrelated economic, social and health-system constraints.

## Conclusion

In Karisimbi Health Zone, women did not delay or discontinue ANC simply because they failed to understand its value. Their care trajectories reflected constrained agency in a setting where pregnancy care competes with daily income, social judgement, transport costs, household responsibilities and variable service confidence. The study therefore shifts the explanation of delayed ANC from individual knowledge to the conditions that make timely and continuous care feasible, acceptable and trustworthy. For research and policy, the implication is that ANC indicators should be interpreted alongside women's economic realities, experience of care and facility readiness, rather than as isolated measures of attendance.

## Conflict of Interest

There is no conflict of interest.

## Ethics Approval

The approval ethic number 10 bis/ESAPU/UNIGOM was provided by the Ethical committee of the University of Goma.

## Authors Contributions

David Munganga Kaseke originated the study, directed its design, oversaw data collection, performed data analysis, and composed the manuscript. Heritier Chelo participated in data collection and field operations. Didier Mukeba Tshialala conducted a critical review of the manuscript. Jerome Mastaki Kambale offered methodological direction and comprehensive oversight.

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## Data Accessibility

Although anonymized to protect participant privacy, the data used in this study may be made available upon request.

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# Acceptance Without Adherence: Health System Bottlenecks and Residual Vaccine Hesitancy in Maternal and Child Healthcare Utilisation in Kwara State, Nigeria

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***Abstract*** *Caregiver acceptance of routine immunisation in Kwara State, Nigeria, is generally high, yet persistent missed doses and incomplete continuity of maternal–child care signal significant coverage bottlenecks. This study examined utilisation patterns, knowledge, attitudes, and residual hesitancy among 1,173 caregivers of children aged 0–23 months across six Local Government Areas to identify independent predictors of zero-dose status, missed immunisation visits, and suboptimal antenatal care attendance. Data were analysed using SPSS v28. While ANC attendance reached 87.4% and facility delivery 80.4%, only 47.3% of ANC attendees completed at least four visits, and 13.9% reached the eight-contact standard. Despite high vaccine safety perceptions (96.6%), 9.7% of children were zero-dose for Penta-1, and 9.1% of caregivers reported missed immunisation visits. In adjusted models, the strongest protective factor against zero-dose status was receiving immunisation reminders, underscoring the critical role of systematic patient tracking in overcoming service-side barriers. Community rumours discouraging immunisation significantly increased the odds of zero-dose status and missed visits, while urban/peri-urban residence was strongly protective against missed visits. These findings demonstrate that in Kwara State, acceptance is not the binding constraint. Closing the immunisation gap requires reliable system performance, structured reminders, and risk communication that actively engages residual safety concerns through trusted interpersonal channels.*

***Keywords*** *Continuity of Care, Routine Immunisation, Vaccine Hesitancy, Zero-Dose Children.*

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## Introduction

Vaccination remains one of the most cost-effective public health interventions for reducing childhood morbidity and mortality. Modelling of the first fifty years of the Expanded Programme on Immunization (EPI) credits vaccines with averting an estimated 154 million deaths globally [1]. Yet significant disparities in coverage persist, with millions of children remaining under-immunised or unvaccinated. The "zero-dose" child - one who has received no dose of routine vaccines, operationalised through the absence of the first dose of diphtheria–tetanus–pertussis-containing vaccine (DTP1 or Penta-1) - has become the principal marker of immunisation inequity [2]. The drivers are not random; they reflect overlapping socio-economic, geographic, political, and behavioural disadvantages, both between and within countries [3].

In response, the global immunisation agenda has shifted toward more equity-oriented approaches. The Immunization Agenda 2030 (IA2030) prioritises underserved populations through tailored strategies, sharper monitoring, and stronger community engagement [4]. Achieving these goals in low- and middle-income countries (LMICs) remains constrained by health-system limitations that hinder equitable access. Geographic barriers - distance to facilities, weak transport networks, difficult terrain - particularly affect remote and marginalised communities [5]. These structural barriers interact with socio-behavioural factors such as low caregiver literacy, misinformation, cultural practices, and social support to produce uneven immunisation outcomes [6].

The burden of zero-dose and under-immunised children remains disproportionately high in sub-Saharan Africa, reflecting disparities in health systems and resource allocation [6]. Progress has been documented in some countries, but spatial inequalities persist in rural, peri-urban, and conflict-affected settings. The COVID-19 pandemic compounded these challenges, disrupting routine services, depressing facility attendance, and increasing the number of zero-dose children across the region [7].

Nigeria carries a disproportionate share of the global zero-dose burden [7]. Despite long-standing national EPI investment, coverage remains highly inequitable, with marked inter- and intra-state variation [7, 8]. National averages mask local realities that only emerge through subnational analysis [8]. Children in rural, riverine, border, and nomadic communities are especially likely to be unvaccinated owing to geodemographic and socio-economic vulnerability.

These disparities are amplified by service-delivery gaps - inadequate infrastructure and human resources, unstable vaccine supply, weak microplanning, and fragmented monitoring [9, 10]. Stock-outs, long waiting times, and irregular outreach deter caregivers from returning for subsequent doses, producing drop-outs and incomplete coverage [11]. Cold-chain and financing bottlenecks further hinder equitable distribution, particularly in low-resource settings [12].

Behavioural determinants also matter. Caregiver trust in health systems, sources of information, sociocultural norms, and gender dynamics all shape health-seeking decisions [2, 11, 13]. Reliance on informal sources of information - community leaders, religious leaders, traditional practitioners - can either reinforce or undermine uptake [14]. Vaccine confidence is frequently eroded by concerns about side effects, rumours, and inconsistent service communication [15].

The COVID-19 pandemic exposed further vulnerabilities in service delivery [16]. Facility closures, staff redeployment, and supply-chain disruption disproportionately affected hard-to-reach populations [17], underscoring the need for resilient health systems capable of sustaining essential services during crises [18].

Gender and socio-cultural factors exacerbate these challenges. Limited maternal agency,

restricted mobility, and competing domestic responsibilities often delay or prevent timely care [19]. Children with disabilities face additional barriers owing to inadequate service adaptation, stigma, and communication gaps, contributing to their over-representation among zero-dose children [20].

In Nigeria, and in mixed urban–rural settings such as Kwara State, a critical evidence gap remains on the interplay between system-side and caregiver-side factors in shaping the continuity of maternal and child healthcare. Available evidence suggests that continuity of care - attaining the recommended number of antenatal visits and adhering to the immunisation schedule - is often suboptimal [21, 22]. Residual vaccine hesitancy, driven by safety concerns and community-level rumours, persists alongside generally favourable caregiver attitudes [15].

This study moves beyond descriptive coverage estimates to identify caregiver- and community-level predictors of three outcomes: zero-dose status for Penta-1, missed immunisation visits in the previous six months, and at-least-four ANC visits (ANC4+). By doing so, it responds to IA2030's call for evidence-based, context-specific action on system and behavioural drivers [4]. The specific objectives were to:

1. Describe maternal and child healthcare utilisation among caregivers of children aged 0–23 months in Kwara State;
2. Assess caregiver knowledge, attitudes, and sources of information regarding routine immunisation; and
3. Identify caregiver- and community-level predictors of zero-dose status, missed immunisation visits, and ANC4+ attainment.

## Materials and Methods

### Study Setting

The study was conducted in Kwara State, located in the North-Central geopolitical zone of Nigeria, with Ilorin as its capital. The state comprises 16 Local Government Areas (LGAs) and presents a mixed settlement profile: densely populated urban and peri-urban centres around Ilorin alongside extensive rural, riverine, and border communities, several of which lie along the state's northern and western frontiers. This gradient shapes both the density of health facilities and the ease with which caregivers can reach immunisation sessions, making the state a useful setting in which to examine how system-side reliability and caregiver-side behaviour interact. The population is religiously and ethnically diverse, with Yoruba, Nupe, Bariba, and Fulani communities among the major groups; routine immunisation and antenatal services are delivered principally through the network of primary health-care facilities coordinated by the State Primary Health Care Development Agency. The six LGAs sampled were drawn to span this urban–rural spectrum so that the findings would reflect the heterogeneity of service access across the state rather than the conditions of any single setting.

### Study Design and Population

The study used a descriptive cross-sectional survey design. The target population comprised caregivers - predominantly mothers - of children aged 0–23 months, the principal decision-makers for presenting a child for vaccination. The sample size was estimated using Cochran's formula for large populations [23], shown in Equation (1):

$$n_0 = \frac{Z^2 pq}{e^2} \qquad (1)$$

where $Z = 1.96$ (95% confidence), $p = 0.5$ (the most conservative estimate of the population proportion), $q = 1 - p = 0.5$, and $e = 0.03$ (3% margin of error). This gives $n_0 = 1{,}067.1$. Adjusting for a 10% non-response allowance (1,067 + 107 = 1,174), a total of 1,173 valid questionnaires were retained for analysis (one excluded for incompleteness).

## Sampling Procedure

A multi-stage sampling procedure captured the diverse geographic and socio-demographic profile of Kwara State. First, the 16 Local Government Areas (LGAs) were stratified into urban/peri-urban and rural categories. Second, six LGAs were randomly selected: three urban/peri-urban (Ilorin East, Ilorin West, and Asa) and three rural (Baruten, Kaiama, and Edu). Third, three wards were randomly selected within each LGA, yielding 18 wards. Fourth, systematic random sampling identified households with eligible children aged 0–23 months within each ward.

## Data Collection Instrument

A structured questionnaire captured socio-demographic variables, maternal and child healthcare utilisation, and caregiver knowledge, attitudes, perceptions, and hesitancy toward routine immunisation. Items were adapted from the Nigeria Demographic and Health Survey (2021) and WHO Immunization Coverage Cluster Survey guidelines. Face and content validity were established through review by experts in public health nursing and in tests and measurement, and item wording was refined accordingly. The questionnaire was administered in English and the predominant local languages (Yoruba, Nupe, Bariba, and Fulfulde) by trained enumerators.

## Outcome Definitions and Statistical Analysis

Three binary outcomes were defined a priori: zero-dose status for Penta-1 (no receipt of the first pentavalent dose among age-eligible children), a missed immunisation visit in the previous six months (caregiver-reported), and antenatal-care continuity. For the antenatal outcome, completion of at least four ANC visits (ANC4+) was retained as the primary analytical benchmark. We recognise that the World Health Organization's 2016 antenatal-care model recommends a minimum of eight contacts (ANC8+) for optimal maternal care [22]. ANC4+ was nonetheless adopted for three context-specific reasons: it remains the operational continuity-of-care indicator embedded in Nigeria's routine health management information system and in the major national survey instruments, including the Demographic and Health Survey; it preserves comparability with the existing Nigerian subnational literature against which our findings are interpreted [21, 22]; and the very low ANC8+ attainment observed in this sample (reported below) would have left too few events for stable multivariable estimation. To avoid an over-optimistic reading of maternal-care quality, ANC8+ attainment is reported descriptively alongside ANC4+, and the continuity gap is interpreted against both standards.

Data were entered into SPSS version 28 after manual completeness checks. Analysis proceeded in three steps. First, descriptive statistics (frequencies and proportions) were computed for all variables; where denominators differed because of item non-response, the valid sample size is reported alongside each variable. Second, bivariate associations between caregiver- and community-level factors and the three outcomes were tested using Pearson's chi-square, with Fisher's exact test where expected cell counts fell below five. Third, multivariable logistic regression was performed for each outcome using predictors that were significant in bivariate analysis ($p < 0.20$) and conceptually relevant: urban residence, education (secondary or higher), religion, occupation, perceived community rumours discouraging immunisation, worry about side effects, and receipt of immunisation reminders. Adjusted odds ratios (aORs) with 95% confidence intervals are reported, with statistical significance set at $p < 0.05$. Reporting follows the STROBE guidance for cross-sectional studies.

## Ethical Considerations

Ethical clearance was obtained from the Kwara State Ministry of Health Ethical Review Committee. Written informed consent was obtained from all caregivers prior to enrolment; participation was voluntary, and respondents could withdraw at any point without penalty. Data were de-identified at the point of entry and stored on password-protected devices accessible only to the research team.

## Results

**Table 1.** Socio-demographic Characteristics of Respondents (N = 1,173)

| Characteristic | n | % |
|---|---|---|
| **Sex of child** | | |
| Female | 606 | 51.7 |
| Male | 560 | 47.7 |
| **Age of child (months)** | | |
| 0–5 | 538 | 45.9 |
| 6–11 | 278 | 23.7 |
| 12–23 | 350 | 29.8 |
| **Relationship to child** | | |
| Mother | 1,109 | 94.5 |
| Father | 26 | 2.2 |
| Grandparent | 24 | 2.0 |
| Other | 7 | 0.6 |
| **Marital status** | | |
| Married / cohabiting | 1,097 | 93.5 |
| Single | 41 | 3.5 |
| Divorced / separated | 21 | 1.8 |
| Widowed | 7 | 0.6 |
| **Highest education (n = 1,003)** | | |
| Senior secondary | 509 | 50.7 |
| Tertiary | 266 | 26.5 |
| Primary | 126 | 12.6 |
| Junior secondary | 88 | 8.8 |
| Quranic / other | 14 | 1.4 |
| **Main occupation** | | |
| Trading | 552 | 47.1 |
| Farming | 246 | 21.0 |
| Unemployed | 113 | 9.6 |
| Artisan | 111 | 9.5 |
| Civil / private employee | 98 | 8.4 |
| Student | 31 | 2.6 |
| Other | 15 | 1.3 |
| **Religion** | | |
| Islam | 1,017 | 86.7 |
| Christianity | 135 | 11.5 |
| Traditional | 13 | 1.1 |
| **Number of children under 5 in household** | | |

| | | |
|---|---|---|
| 1 | 515 | 43.9 |
| 2 | 508 | 43.3 |
| ≥3 | 140 | 11.9 |

***Note:*** *N = 1,173. Cell counts are based on valid (non-missing) responses for each characteristic; denominators therefore vary across variables owing to item non-response (for example, highest education, n = 1,003). Percentages are computed on the valid responses for each characteristic and may not sum to 100% because of rounding and the exclusion of missing values.*

The socio-demographic profile (Table 1) shows a predominantly maternal sample (94.5%), with most respondents married or cohabiting (93.5%) and Muslim (86.7%). Educational attainment was moderate: over half had senior secondary education and 26.5% had tertiary education. Trading (47.1%) and farming (21.0%) were the main occupations. Children were almost evenly distributed by sex (51.7% female, 47.7% male), and 45.9% were under six months old.

**Table 2.** Maternal and Child Healthcare Utilisation (N = 1,173)

| **Indicator** | **n** | **%** |
|---|---|---|
| **Antenatal and Delivery** | | |
| ANC attendance – Yes | 1,025 | 87.4 |
| ANC attendance – No | 121 | 10.3 |
| ANC visits (1–3) | 521 | 44.4 |
| ANC visits (4–7) | 304 | 25.9 |
| ANC visits (≥8) | 163 | 13.9 |
| Place of delivery – Public facility | 765 | 65.2 |
| Place of delivery – Private facility | 178 | 15.2 |
| Place of delivery – Home | 151 | 12.9 |
| Place of delivery – TBA / Mission | 53 | 4.5 |
| **Child Health-Seeking Behaviour (last 6 months)** | | |
| Facility visits – None | 99 | 8.4 |
| Facility visits – Once | 291 | 24.8 |
| Facility visits – 2–3 times | 481 | 41.0 |
| Facility visits – ≥4 times | 213 | 18.2 |
| First care-seeking – Public facility | 841 | 71.7 |
| First care-seeking – Private facility | 187 | 15.9 |
| First care-seeking – PPMV / Pharmacy | 98 | 8.4 |
| First care-seeking – Traditional healer | 37 | 3.2 |
| **Immunisation Service Experience** | | |
| Missed vaccination visit – No | 1,050 | 89.5 |
| Missed vaccination visit – Yes | 107 | 9.1 |
| Main reason (missed) – Vaccine stock-out | 40 | 3.4 |
| Main reason (missed) – Long waiting time | 24 | 2.0 |
| Main reason (missed) – Child's illness | 18 | 1.5 |
| Main reason (missed) – Session cancelled | 10 | 0.9 |
| Treatment rating – Very good / good | 1,121 | 95.5 |
| Treatment rating – Fair / poor | 35 | 3.0 |

| | | |
|---|---|---|
| Health worker discussed RI – Yes | 1,121 | 95.6 |
| Zero-dose Penta-1 (age-eligible, N = 943) | 91 | 9.7 |

*ANC = antenatal care; PPMV = patent and proprietary medicine vendor; RI = routine immunisation; TBA = traditional birth attendant.*

Utilisation of maternal and child health services was generally high but uneven (Table 2). ANC attendance reached 87.4% and facility delivery 80.4% (public 65.2%; private 15.2%). However, continuity fell away sharply with each additional contact: 44.4% of respondents reported one to three ANC visits, 25.9% completed four to seven, and only 13.9% reached the WHO-recommended eight or more contacts (ANC8+). Overall, 39.8% of all women - 47.3% of ANC attendees - completed at least four visits (ANC4+). The drop from ANC4+ to ANC8+ underscores that the continuity gap is considerably wider when measured against the current eight-contact standard. About one in twelve children (8.4%) had no facility visit in the previous six months. Reported quality of interaction with health workers was high (95.5% rated it very good or good), and 95.6% of caregivers had been engaged on routine immunisation by a health worker. Despite this, 9.1% of caregivers had missed an immunisation visit in the previous six months, primarily owing to vaccine stock-outs (3.4%) and long waiting times (2.0%). Among age-eligible children, 9.7% were zero-dose for Penta-1.

**Table 3.** Caregiver Knowledge and Information Sources for Routine Immunisation (N = 1,173)

| **Indicator** | **n** | **%** |
|---|---|---|
| **Awareness and Knowledge** | | |
| Heard of routine immunisation – Yes | 1,152 | 98.2 |
| Main purpose – Prevent disease | 1,102 | 93.9 |
| Knows where RI is offered – Yes | 1,138 | 97.0 |
| Knows vaccination starts at birth | 1,135 | 96.8 |
| Receives immunisation reminders – Yes | 1,029 | 87.7 |
| **Information Sources (multiple responses)** | | |
| Health worker | 1,016 | 86.6 |
| Family / community / religious leader | 646 | 55.1 |
| Friends / neighbours | 591 | 50.4 |
| Radio | 213 | 18.2 |
| Social media | 201 | 17.1 |
| Television | 73 | 6.2 |

*RI = routine immunisation.*

Awareness and knowledge of routine immunisation were near-universal among respondents: 98.2% had heard of routine immunisation, 93.9% identified disease prevention as its main purpose, and 96.8% knew that vaccination should begin at birth (Table 3). Health workers were the dominant source of information (86.6%), followed by family and community leaders (55.1%). Mass media played a marginal role (radio 18.2%, social media 17.1%, television 6.2%), indicating that information flow in this setting is principally interpersonal.

**Table 4.** Caregiver Attitudes, Perceptions and Hesitancy Toward Routine Immunisation (N = 1,173)

| Indicator | n | % |
|---|---|---|
| **Vaccine Confidence (agree / strongly agree)** | | |
| Vaccines are safe | 1,133 | 96.6 |
| Vaccines are effective | 1,121 | 95.6 |
| RI is important even when child is healthy | 1,097 | 93.5 |
| Family supports routine immunisation | 1,090 | 92.9 |
| **Hesitancy and Community Factors** | | |
| Worry about vaccine side effects (agree / strongly agree) | 608 | 51.8 |
| Community rumours discourage RI (agree / strongly agree) | 451 | 38.4 |
| **Service Quality Perception** | | |
| Health workers treat caregivers respectfully | 1,092 | 93.1 |

*RI = routine immunisation.*

Attitudes towards routine immunisation were strongly positive (Table 4): 96.6% of caregivers considered vaccines safe, 95.6% effective, and 93.5% endorsed vaccination even for apparently healthy children. Family support was reported at 92.9%, and 93.1% felt health workers treated caregivers respectfully. Two markers of residual hesitancy persisted: 51.8% of caregivers worried about vaccine side effects, and 38.4% agreed that community rumours discourage routine immunisation.

**Table 5.** Multivariable Logistic Regression: Predictors of Zero-Dose Status, Missed Immunisation Visit, and ANC4+ Attainment

| Predictor | Zero-dose Penta-1 (n = 830) aOR (95% CI), p | Missed immunisation visit (n = 996) aOR (95% CI), p | ANC4+ attainment (n = 871) aOR (95% CI), p |
|---|---|---|---|
| Urban/peri-urban residence | 0.86 (0.51–1.45), 0.574 | 0.23 (0.13–0.42), <0.001 | 1.59 (1.19–2.12), 0.002 |
| Education ≥ secondary | 0.56 (0.33–0.96), 0.034 | 0.64 (0.39–1.07), 0.088 | 1.49 (1.06–2.11), 0.024 |
| Religion (Islam vs other) | 0.77 (0.41–1.47), 0.429 | 1.20 (0.64–2.26), 0.563 | 0.79 (0.53–1.19), 0.264 |
| Formal-sector occupation | 1.52 (0.79–2.93), 0.208 | 1.36 (0.72–2.59), 0.347 | 1.07 (0.71–1.60), 0.754 |
| Community rumours discourage RI | 1.98 (1.15–3.40), 0.014 | 4.06 (2.46–6.70), <0.001 | 1.03 (0.75–1.42), 0.834 |
| Worry about side effects | 0.96 (0.56–1.63), 0.867 | 1.08 (0.66–1.75), 0.764 | 0.61 (0.45–0.82), 0.001 |
| Immunisation reminders received | 0.15 (0.08–0.28), <0.001 | 2.07 (0.72–5.99), 0.179 | 0.68 (0.39–1.17), 0.158 |

*aOR = adjusted odds ratio; CI = confidence interval; RI = routine immunisation; ANC4+ = at least four antenatal-care visits. Each outcome was modelled in the affirmative direction (presence of zero-dose status, occurrence of a missed visit, attainment of ANC4+); an aOR below 1 therefore denotes lower odds of the named outcome. Models adjusted for all listed variables. Statistical significance at p < 0.05.*

The multivariable models in Table 5 reveal patterns that descriptive figures alone do not capture. All three outcomes were modelled in the affirmative direction - that is, as the presence of zero-dose status, the occurrence of a missed visit, and the attainment of ANC4+ - so that an adjusted odds ratio below 1 denotes lower odds of the named outcome. For zero-dose status, the single strongest independent protective factor was receipt of immunisation reminders (aOR 0.15; 95% CI 0.08–0.28; $p < 0.001$): children of caregivers who received reminders were approximately 85% less likely to be zero-dose, holding other factors constant. Education at secondary level or higher was independently protective (aOR 0.56; 0.33–0.96; $p = 0.034$), while perceived community rumours nearly doubled the odds of zero-dose status (aOR 1.98; 1.15–3.40; $p = 0.014$).

For missed immunisation visits, urban/peri-urban residence was strongly protective (aOR 0.23; 0.13–0.42; $p < 0.001$), and community rumours were the dominant behavioural driver, quadrupling the odds of a missed visit (aOR 4.06; 2.46–6.70; $p < 0.001$). For ANC4+ attainment - where the modelled outcome is completion of four or more visits - urban residence (aOR 1.59; 1.19–2.12; $p = 0.002$) and secondary-or-higher education (aOR 1.49; 1.06–2.11; $p = 0.024$) were facilitators. Worry about vaccine side effects carried an aOR of 0.61 (0.45–0.82; $p = 0.001$) for this outcome; because the outcome is attainment, an odds ratio below 1 indicates that caregivers who worried about side effects were significantly less likely to complete four ANC visits. This suggests that hesitancy spills over from immunisation into antenatal continuity of care.

## Discussion

### Utilisation of Healthcare and Its Implications for Immunisation

Caregivers in this study had substantial contact with the formal health system. Most respondents attended antenatal care (87.4%), and 80.4% delivered in a health facility. In addition, 89.5% reported not having missed any immunisation visit in the preceding six months. These findings suggest that many caregivers had repeated opportunities to interact with maternal and child health services before and after delivery. This is consistent with evidence from similar Nigerian and West African settings, where ANC attendance provides an important entry point for immunisation counselling, birth-dose planning, and early linkage to routine immunisation services [24, 25]. Evidence from other low-resource settings also shows that frequent contact with health services is associated with better immunisation uptake, largely because each encounter creates an opportunity for education, reminder, referral, and follow-up [26, 27].

However, access alone did not guarantee continuity of care. Although initial contact with services was relatively high, only 47.3% of ANC attendees completed at least four visits, and just 13.9% of respondents reached the eight-contact standard now recommended by WHO [22]; 9.1% of caregivers reported missing an immunisation visit, mainly because of vaccine stock-outs and long waiting times. Among age-eligible children, 9.7% had not received Penta-1, placing them in the zero-dose category. The gap is therefore even more pronounced when continuity is benchmarked against ANC8+ rather than ANC4+, reinforcing the central argument of this paper: the binding constraint is adherence and retention, not first contact.

This pattern of high initial uptake but incomplete follow-through, reflects the "missed-opportunity" paradox reported in several sub-Saharan African settings [28]. It suggests that the major barrier is not simply whether caregivers can access services, but whether the health system can retain them through reliable, timely, and client-responsive service delivery. The implication is that improving adherence and retention is as important as expanding access if immunisation-completion targets are to be achieved [29].

Multivariable analysis showed that urban/peri-urban residence was the strongest protective factor against missed visits (aOR 0.23). This suggests that continuity of immunisation is driven less by caregiver-level characteristics and more by system-level reliability such as vaccine availability, frequency of sessions, predictable service hours, and easier physical access to facilities. Receipt of immunisation reminders was also strongly protective, reducing the odds of zero-dose status by 85% in the adjusted model. This reinforces the value of structured demand-generation and is consistent with IA2030-aligned programmes in which reminders, caregiver tracking, and proactive follow-up improve uptake and reduce missed opportunities [30]. Recent Nigerian evidence strengthens this interpretation: a quasi-experimental study in Borno State found that parental SMS reminders significantly improved infant immunisation coverage and timeliness and reduced caregiver-reported barriers [31], while a qualitative evaluation of an SMS reminder system in Kebbi State, north-western Nigeria, identified the operational conditions - phone ownership, network reliability, caregiver literacy, and language of messaging - that determine whether such systems actually reach their intended users [32]. The high self-reported reminder coverage in our sample (87.7%) should therefore be interpreted with attention to these local feasibility constraints.

## Knowledge and Information Sources

Awareness of routine immunisation was almost universal, with 98.2% of caregivers reporting awareness and 93.9% correctly identifying disease prevention as its primary purpose. These figures are higher than those reported in many comparable settings, where limited knowledge remains an important constraint to immunisation coverage [33]. The high awareness observed here likely reflects the cumulative effect of sustained social mobilisation, health education, and community engagement by the Government of Nigeria and partner agencies [34].

Information flow in this setting was predominantly interpersonal. Health workers were the main source of immunisation information (86.6%), followed by family members, community and religious leaders (55.1%), and friends or neighbours (50.4%). By contrast, mass media played a much smaller role (radio 18.2%, social media 17.1%, television 6.2%). This pattern highlights the central role of trusted human channels in shaping immunisation decisions in low-resource Nigerian settings and suggests that interventions aimed at addressing misinformation should not rely on mass-media campaigns alone, but should be delivered through the same trusted interpersonal networks that caregivers already use.

High knowledge did not, however, translate uniformly into adherence. The continued occurrence of zero-dose children and missed visits, despite near-universal awareness, reflects the knowledge–behaviour gap described in other settings. Information is therefore necessary but not sufficient for full immunisation. Programme interventions should move beyond general awareness creation toward schedule completion, timely return for subsequent doses, and the active correction of specific misconceptions.

## Attitudes, Confidence, and Residual Hesitancy

Caregivers generally expressed strong confidence in vaccination. Most considered vaccines safe (96.6%) and effective (95.6%), and 93.5% supported routine immunisation for children who appeared healthy. These findings are consistent with the high vaccine acceptance reported in several sub-Saharan African settings, although the regional picture is becoming increasingly heterogeneous [35]. The value of vaccination also extends beyond infectious-disease prevention to broader child health and developmental outcomes [36].

Despite this confidence, residual hesitancy remains, revealing a nuanced landscape of behavioural barriers. More than half of caregivers expressed concern about vaccine side effects, and 38.4% identified community rumours as a deterrent to routine immunisation. These factors appear to operate through distinct pathways. Multivariable models indicate that community rumours are independently associated with both zero-dose status and missed visits, whereas private concerns about side effects are linked more specifically to non-attainment of ANC4+. This divergence suggests that collective misinformation poses a greater threat to routine-immunisation coverage than individual safety anxieties - a pattern consistent with broader evidence on the social production of vaccine hesitancy [37] and with Nigerian studies documenting how community-level misconceptions and rumours about childhood vaccines depress demand independently of individual safety concerns [11].

Hesitancy in this context is therefore better understood as a continuum than a simple accept–reject binary [15]. Most caregivers accept vaccination, but some continue to hold specific concerns which, when reinforced by community rumour networks, may result in delayed or missed doses. Effective risk communication should engage these concerns directly, using the trusted interpersonal channels that already dominate information flow in the study setting.

### Strengths and Limitations

This study has several strengths: a large multi-stage sample spanning urban/peri-urban and rural LGAs, locally validated instruments administered in the major languages of the state, and multivariable models that separate caregiver-level from community-level drivers. Several limitations should nonetheless temper interpretation. The cross-sectional design precludes causal inference; the associations reported here describe correlation, not proven effect. Most indicators were caregiver-reported and were not systematically verified against home-based or facility immunisation records, introducing potential recall bias - particularly for events such as missed visits over the preceding six months - and social-desirability bias in the reporting of attitudes, adherence, and respectful treatment, which may inflate favourable responses. Item non-response produced varying denominators across variables, as noted in the tables. Finally, although the six study LGAs were purposively spread across the urban–rural gradient, they may not capture the full heterogeneity of all 16 LGAs. Reporting followed the STROBE guidance for observational studies to support transparency and replicability.

## Conclusion

In Kwara State, low acceptance is not the principal constraint to routine immunisation. Caregivers reported high awareness, strong vaccine confidence, and high uptake of first-contact maternal and child health services. Yet a meaningful minority of children remained zero-dose, and continuity of care was uneven - markedly so when benchmarked against the eight-contact antenatal standard.

The multivariable findings point to three practical levers for programme improvement. First, system-side reliability must be strengthened through consistent vaccine availability, reduced waiting times, and predictable immunisation sessions, particularly in rural LGAs where missed visits are concentrated. Second, caregiver reminder systems should be expanded, given their strong protective effect against zero-dose status, with attention to the local feasibility conditions that govern their reach. Third, risk communication should directly address community rumours, which were strongly associated with both zero-dose status and missed visits.

Closing the remaining gap will require a shift in programme emphasis: from access alone to adherence, from awareness to completion, and

from broadcast messaging to sustained engagement through the trusted interpersonal channels that shape caregiver decisions.

## Recommendations

1. Strengthen reminder systems for routine immunisation - SMS, voice calls, and in-person follow-up by ward-level focal persons - prioritising rural LGAs and the 12.3% of caregivers who currently receive no reminders.
2. Improve system reliability by reducing vaccine stock-outs and waiting times at primary health facilities, particularly in rural LGAs where missed visits cluster.
3. Develop and field-test rumour-response protocols delivered through health workers, community leaders, and religious leaders - the dominant information channels in this setting - to engage residual safety concerns directly rather than displace them.
4. Integrate ANC continuity into immunisation programming: women who worry about vaccine side effects are also less likely to complete ANC4+, indicating that hesitancy interventions should span the maternal–child care continuum.
5. Embed routine collection of zero-dose indicators in subnational monitoring, with ward-level disaggregation, to identify and respond to hotspots within ostensibly high-coverage LGAs.

## Conflict of Interest

The authors declare no financial, commercial, legal, or professional relationships that could have influenced this research.

## Ethical Approval

Ethical clearance was obtained from the Kwara State Ministry of Health Ethical Review Committee. Written informed consent was obtained from all participants before enrolment. Participation was voluntary, and respondents could withdraw at any point without penalty. Data were de-identified at the point of entry and stored on password-protected devices accessible only to the research team.

## Author Contributions

EEE conceptualised and designed the study; OOS reviewed the manuscript; AAE participated in drafting the manuscript; and KFL participated in data collection and review of the final manuscript. All authors read and approved the final version.

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## Data Availability

The de-identified datasets generated and analysed during this study are available from the corresponding author upon reasonable request. Household-level GPS coordinates have been aggregated to the ward level for reporting in order to protect participant privacy and are not publicly shared.

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# Determinants of Health Communication Quality in Diabetes Management in Bamenda Health District Cameroon

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***Abstract*** *Effective communication is essential in diabetes care because it improves patients' understanding of their condition, treatment adherence, and satisfaction with care. This study assessed communication practices, provider–patient interaction, and barriers affecting perceived communication quality among diabetic patients in the Bamenda Health District, Cameroon. A cross-sectional study involving 149 diabetic patients was conducted using structured questionnaires. Data were analyzed using descriptive statistics, Pearson's correlation, one-way ANOVA, and multivariate regression techniques. Findings showed that 86% of participants reported that healthcare providers frequently used simple and understandable language ($p < 0.001$), while only 15% experienced the explain-back method ($p = 0.007$). Although 57% perceived providers as empathetic ($p < 0.001$), only 35.6% reported active involvement in decision-making. Significant positive relationships existed between perceived communication quality and receiving regular updates ($r = 0.407$, $p < 0.001$), consideration of patient emotions ($r = 0.344$, $p < 0.001$), opportunities to ask questions ($r = 0.295$, $p < 0.001$), use of visual aids ($r = 0.240$, $p = 0.003$), and encouragement of self-care practices ($r = 0.262$, $p = 0.001$). One-way ANOVA revealed significant effects of provider–patient interaction factors such as consultation time, active listening, and compassion ($p < 0.001$). Multivariate analysis identified the use of visual aids ($\beta = 0.050$, $p = 0.030$) and adequate consultation time ($\beta = 0.087$, $p = 0.014$) as positive predictors of communication quality, whereas time constraints negatively affected communication ($\beta = -0.081$, $p = 0.009$).*

***Keywords*** *Communication Practices, Diabetes Care, Patient Perception, Provider–Patient Interaction.*

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## Introduction

Diabetes mellitus is increasing worldwide and is affecting low- and middle-income countries the most, especially in sub-Saharan Africa. According to the latest International Diabetes Federation estimates, approximately 589 million adults were living with diabetes globally in 2025, with the greatest increases occurring in low- and middle-income countries [1]. Within the Cameroonian context, diabetes represents a significant contributor to both morbidity and mortality, with many patients exhibiting suboptimal glycemic control [2]. Recent evidence from the North West Region of Cameroon demonstrated that healthcare utilization among people with type 2 diabetes is influenced by accessibility of services, continuity of care, and patient-related factors, all of which may affect disease outcomes and patient engagement in care [3]. This situation is not solely attributable to limitations in access to treatment but is also closely linked to gaps in patient knowledge, health literacy, and engagement in self-management practices [2]. Current studies have further shown that diabetes knowledge and medication adherence remain important determinants of treatment outcomes among patients with type 2 diabetes mellitus [4].

In this regard, the management of diabetes extends beyond biomedical interventions and requires a more comprehensive approach that incorporates effective provider–patient communication. Evidence suggests that the quality of interaction between healthcare providers and patients plays a critical role in shaping treatment adherence, patient satisfaction, and overall clinical outcomes [5, 6]. New evidence continues to confirm that patient-centred communication significantly improves self-management behaviours, treatment adherence, and glycaemic outcomes among individuals living with diabetes [7].

Although the importance of effective health communication in enhancing treatment adherence, self-management, and clinical outcomes is well established, its integration into routine healthcare practice remains inconsistent. In many settings, communication continues to be predominantly provider-driven, with limited opportunities for active patient involvement, minimal use of visual or interactive tools, and insufficient consideration of patients' socio-cultural realities. This approach undermines the potential benefits of communication in chronic disease management. Existing literature consistently demonstrates that patient-centered communication is associated with improved patient understanding, satisfaction, and health outcomes, particularly in the context of long-term conditions [8, 9]. However, translating these principles into practice within resource-constrained environments such as Cameroon presents significant challenges. Factors such as language diversity, low levels of health literacy, and high patient load among healthcare providers often limit the effectiveness of communication strategies and reduce opportunities for meaningful patient engagement [10].

Evidence from studies conducted across African settings indicates that suboptimal provider–patient interaction is a significant contributor to poor treatment adherence and adverse health outcomes in chronic disease management [11, 12]. Emerging research further highlights that participatory communication approach, which actively involve patients in the care process, are associated with improved diabetes control and enhanced self-management practices [13].

Despite these insights, much of the existing literature tends to address communication within the broader context of health service delivery, with limited attention given to the specific factors that determine communication quality in chronic disease care. In the Cameroonian context, empirical evidence remains particularly scarce, especially quantitative studies that examine communication practices, provider–patient

interaction, and related barriers from the patient's perspective. This lack of context-specific evidence constrains the ability to develop interventions that are responsive to the realities of diabetes care within the local health system.

This study was undertaken to address the identified gap by examining the determinants of health communication quality in diabetes management within the Bamenda Health District. It specifically investigates communication practices employed by healthcare providers, the nature of provider–patient interactions, and the barriers that influence effective communication. Using a quantitative design, the study generates empirical evidence on the extent to which these factors shape patients' perceptions of communication quality.

A key contribution of this study is its context-specific and integrated assessment of communication within routine diabetes care in public healthcare settings in Cameroon. By bringing together multiple dimensions of communication within a single analytical framework and applying robust statistical techniques, the study identifies critical predictors of communication quality. The findings provide practical insights that can support the development of targeted strategies to strengthen patient-centered communication and improve diabetes care outcomes.

While this study offers valuable contributions, certain limitations should be acknowledged. The cross-sectional design restricts the ability to establish causal relationships, and reliance on patient-reported data may be subject to recall bias. Nonetheless, the findings provide meaningful insights into areas requiring improvement in communication practices within diabetes care.

In the Cameroonian context, the growing burden of diabetes has not been matched by sufficient evidence on the effectiveness of communication during routine clinical care. Existing knowledge remains limited regarding the factors that influence provider–patient interactions, thereby constraining the development of targeted strategies to enhance patient understanding, adherence, and overall health outcomes.

Against this background, the study examined the determinants of health communication quality in diabetes management in the Bamenda Health District, with particular emphasis on communication practices, provider–patient interaction, and barriers to effective communication.

## Materials and Methods

The study was carried out in the Bamenda Health District, located in the North West Region of Cameroon, a semi-urban area characterized by a rising burden of chronic conditions, including diabetes mellitus. Data collection was undertaken in two public health facilities, the Bamenda Regional Hospital and the Nkwen District Hospital, which serve as key referral centers within the district and host established diabetic clinics. These facilities were purposively selected based on their patient volume and their central role in the provision of diabetes care.

A descriptive and analytical cross-sectional design was employed to examine the determinants of health communication quality among patients with diabetes. The study assessed communication practices, provider–patient interactions, and barriers to effective communication, with particular attention to how these factors shape patients' perceptions of communication quality.

The study population comprised adult patients diagnosed with diabetes and receiving care in the selected facilities. Eligibility was restricted to patients who had been on treatment for a minimum of six months, thereby ensuring adequate exposure to routine interactions with healthcare providers. Participants were recruited consecutively during routine clinic visits, and all eligible patients present during the data collection period were invited to

participate. This approach allowed for near-complete coverage of the accessible patient population within the study timeframe. In total, 149 patients consented and were included in the study.

Data were collected using a structured questionnaire developed to examine communication practices in diabetes care, focusing on provider–patient interaction and communication barriers. Responses were captured using a Likert-type scale reflecting frequency of occurrence. Given that the study population included participants with varying levels of literacy, trained research assistants administered the questionnaire verbally for some participants, while those who could read and write completed it independently.

The questionnaire was pre-tested among diabetic patients at Ndop District Hospital to improve clarity and contextual relevance. Content validity was established through review by supervisor, and reliability was assessed using Cronbach's alpha, which indicated satisfactory internal consistency across all sections.

The study examined communication practices, quality of provider–patient interactions, and communication-related constraints as explanatory variables, while patients' perception of communication quality was treated as the outcome variable. Sociodemographic and clinical characteristics were accounted for as control factors during analysis.

Following data verification and cleaning, statistical analysis was performed using SPSS version 21 software. Descriptive measures were applied to summarize participant characteristics and key study variables. Relationships between variables were explored using Pearson's correlation, while group differences were assessed through one-way analysis of variance. To identify factors associated with perceived communication quality, binary logistic regression was conducted. A multivariate model was subsequently developed to isolate independent predictors, with results reported as adjusted odds ratios and corresponding confidence intervals. Statistical significance was determined at $p < 0.05$.

## Results

### Socio-Demographic Data of Participants

Table 1 presents the socio-demographic characteristics of the diabetic clients who participated in the quantitative phase of the study.

**Table 1.** Sociodemographic Data of Participants

| SN | Variable | Options | Frequency | Percentages (%) |
|---|---|---|---|---|
| 1. | Age category | 20-40 | 13 | 8.7 |
| | | 41-60 | 49 | 32.9 |
| | | >60 | 87 | 58.4 |
| 2. | Gender | Male | 48 | 32.2 |
| | | Female | 101 | 67.8 |
| 3. | Level of education | None | 33 | 22.1 |
| | | Primary | 60 | 40.3 |
| | | Secondary | 26 | 17.4 |
| | | High school | 17 | 11.4 |
| | | University and above | 13 | 8.7 |

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Most of the participants were older adults, with 58.4% aged above 60 years, 32.9% between 41 and 60 years, and only 8.7% between 20 and 40 years. Females were the majority (67.8%), while males made up 32.2%. In terms of education, many participants had low educational levels, with 40.3% having primary education and 22.1% having no formal education, while only a small proportion reached higher education.

The mean age was 61.29 years, with a median of 63 and a standard deviation of 13.43, showing that most participants were around their 60s, with some variation. The study population was mainly older adults, with more women than men and generally low levels of education.

**Table 2.** Frequency Distribution of the Clinical Profile of Respondents

| Sn | Variable | Options | Frequency | Percentages (%) |
|---|---|---|---|---|
| 1. | Duration of diagnosis | 6-12 months | 11 | 7.4 |
| | | 1-2 years | 27 | 18.1 |
| | | More than 2 years | 111 | 74.5 |
| 2. | Type of treatment | Oral diabetic medication | 127 | 85.2 |
| | | Insulin injectable | 6 | 4.0 |
| | | Both oral and injectable | 16 | 10.7 |
| 3. | Frequency of consultation | Once a week | 10 | 6.7 |
| | | Once a month | 106 | 71.1 |
| | | Every 3-6months | 23 | 15.4 |
| | | Only when i have a problem or complication | 10 | 6.7 |

From Table 2 above most participants (74.5%) had been living with diabetes for more than two years, while 18.1% had the condition for 1–2 years and 7.4% for less than one year. The majority (85.2%) were on oral medication, 10.7% used both oral drugs and insulin, and only 4.0% relied on insulin alone.

In terms of follow-up, most patients (71.1%) attended consultations monthly, 15.4% every 3–6 months, and 6.7% either weekly or only when complications occurred.

These findings indicate that most patients are long-term cases who are regularly followed up and mainly managed with oral treatment, although a small group still seeks care only when problems arise.

## Communication Practices of Healthcare Providers

This section examines how healthcare workers at Bamenda Regional Hospital and District Hospital Nkwen communicate with diabetic patients, focusing on the methods, tools, and techniques they use to share information effectively.

**Table 3.** Frequency Distribution of Communication Practices used by Healthcare Providers

| | Variable | Never n (%) | Rarely | Sometimes | Often | Always |
|---|---|---|---|---|---|---|
| 1. | Clarity of language | 3 (2%) | 0 (0%) | 19 (13%) | 47 (32%) | 80 (54%) |
| 2. | Use of visual aids | 90 (60%) | 7 (5%) | 33 (22%) | 11 (7%) | 8 (5%) |
| 3. | Understandability of written materials | 137 (92%) | 5 (3%) | 2 (1%) | 5 (3%) | 0 (0%) |
| 4. | Use of digital tools technological accessibility | 131 (88%) | 6 (4%) | 1 (1%) | 6 (4%) | 5 (3%) |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5. | Teach-back method | 43 (29%) | 8 (5%) | 50 (34%) | 26 (17%) | 22 (15%) |
| 6. | Follow-up instructions | 9 (6%) | 5 (3%) | 27 (18%) | 47 (32%) | 61 (41%) |
| 7. | Empathy and consideration of feelings | 8 (5%) | 2 (1%) | 32 (22%) | 50 (34%) | 57 (38%) |
| 8. | Cultural sensitivity | 8 (5%) | 9 (6%) | 33 (22%) | 34 (23%) | 65 (44%) |
| 9. | Consideration of educational level | 2 (1%) | 5 (3%) | 20 (13%) | 28 (19%) | 94 (63%) |
| 10 | Opportunities for questions | 8 (5%) | 5 (3%) | 44 (30%) | 22 (15%) | 70 (47%) |
| 11 | .Effectiveness of explanations | 1 (1%) | 6 (4%) | 22 (15%) | 31 (21%) | 89 (60%) |
| 12 | Consistency and accuracy of information | 7 (5%) | 5 (3%) | 13 (9%) | 29 (20%) | 95 (64%) |
| 13 | Encouragement for self-care | 32 (22%) | 13 (9%) | 31 (21%) | 24 (16%) | 49 (33%) |
| 14 | Timely follow-ups/updates | 1 (1%) | 11 (7%) | 57 (38%) | 33 (22%) | 47 (32%) |

Table 3 shows that most patients reported that healthcare providers communicated clearly, with 54% saying clear language was always used. However, supportive communication tools were rarely used. About 60% said visual aids were never used, 92% never received written materials, and 88% reported no use of digital tools.

The teach-back method was also not common, with only 15% saying it was always used. On the positive side, providers showed good interpersonal skills. About 38% of patients always experienced empathy, 44% reported cultural sensitivity, and 63% said their educational level was considered during communication.

Patient engagement was moderate. Around 47% said they were always given the chance to ask questions, and 60% found explanations clear and effective.

However, only 33% reported receiving timely follow-up, and the same proportion said communication always encouraged self-care.

These findings show that while verbal communication is generally good, the use of tools, follow-up, and patient involvement still needs improvement.




**Figure 1.** Patient's Ratings of Communication Practices used by Healthcare Providers

Figure 1 shows how patients rated the overall quality of healthcare providers' communication practices. The majority of responses were Fair (57%), indicating that many patients perceived communication practices to be moderately effective. Ratings of Excellent (47%) and Good (33%) reflect generally strong communication by providers. However, a smaller proportion rated communication as Poor (11%) or Very Poor (1%), highlighting dissatisfaction among a minority of respondents. These results suggest that while communication practices are generally viewed positively, there is a need for greater consistency and improvement to ensure high-quality communication across all patient interactions.

**Table 4.** Summary of all Clients' Ratings Across all Communication Practices

| **Answer Option Frequency of Responses** | | **Percentage (%)** |
|---|---|---|
| Never | 480 | 29.3% |
| Rarely | 87 | 5.3% |
| Sometimes | 384 | 23.5% |
| Often | 393 | 24.0% |
| Always | 742 | 45.3% |
| **Total** | **1,639** | **100%** |
| | Mean score | **3.40** |
| | Median score | **4.00** |
| | Standard deviation | **1.5** |

Table 4 summarizes all 1,639 patient responses across the 14 items assessing provider communication practices. The highest proportion of responses fell under the "Always" category (45.3%), indicating that many clients consistently experienced effective communication. Another 24.0% of responses were marked "Often," reflecting frequent but not universal satisfaction with communication efforts.

However, a notable 23.5% of responses fell under "Sometimes," pointing to inconsistency in the communication approach. Additionally, lower ratings of "Rarely" (5.3%) and "Never" (29.3%) indicate that some clients experienced minimal or no engagement in key communication areas.

The mean score of 3.40 suggests that, on average, patients experienced communication practices between "Sometimes" and "Often," indicating a moderately positive but inconsistent experience. The median score of 4.00 ("Often") shows that at least half of the patients reported frequent positive communication behaviors, such as clarity, empathy, and follow-up instructions. However, the standard deviation of 1.55 reflects high variability in responses, suggesting that patient experiences were not uniform, some encountered consistently strong communication, while others reported significant gaps. This calls for more standardized and dependable communication practices across all diabetes care settings.

## Provider-Patient Communication Interactions

This section presents findings on how patients interact with their healthcare providers during diabetes care, focusing on key relationship factors like empathy, trust, and respect, as well as communication behaviors such as clear explanations, active listening, and shared decision-making, to understand how these interactions shape the patient's overall care experience.

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**Table 5.** Frequency Distribution of Provider-Patient Communication Interactions

| Code | Variable | Never | Rarely | Sometimes | Often | Always |
|---|---|---|---|---|---|---|
| **1.** | Enough time for discussion | 9 (6.0%) | 4 (2.7%) | 42 (28.2%) | 43 (28.9%) | 51 (34.2%) |
| **2.** | Active listening | 4 (2.7%) | 6 (4.0%) | 42 (28.2%) | 28 (18.8%) | 69 (46.3%) |
| **3.** | Empathy, kindness, and respect | 4 (2.7%) | 8 (5.4%) | 29 (19.5%) | 23 (15.4%) | 85 (57.0%) |
| **4.** | Shared decision-making | 18 (12.1%) | 20 (13.4%) | 23 (15.4%) | 35 (23.5%) | 53 (35.6%) |
| **5.** | Comfort in sharing sensitive information | 21 (14.1%) | 9 (6.0%) | 18 (12.1%) | 32 (21.5%) | 69 (46.3%) |
| **6.** | Clarity of explanation and options | 7 (4.7%) | 12 (8.1%) | 29 (19.5%) | 24 (16.1%) | 77 (51.7%) |
| **7.** | Empathy and rapport | 11 (7.4%) | 12 (8.1%) | 33 (22.1%) | 32 (21.5%) | 61 (40.9%) |
| **8.** | Privacy and confidentiality | 1 (0.7%) | 4 (2.7%) | 20 (13.4%) | 32 (21.5%) | 92 (61.7%) |
| **9.** | Trust in provider | 7 (4.7%) | 9 (6.0%) | 19 (12.8%) | 30 (20.1%) | 84 (56.4%) |
| **10.** | Consideration of lifestyle and preferences | 25 (16.8%) | 12 (8.1%) | 29 (19.5%) | 25 (16.8%) | 58 (38.9%) |
| **11.** | Emotional support | 4 (2.7%) | 7 (4.7%) | 39 (26.2%) | 32 (21.5%) | 67 (45.0%) |

Table 5 shows that most patients reported positive communication interactions with providers.

Respect for privacy was the highest-rated aspect, with 61.7% selecting "Always," followed by empathy and respect (57.0%) and trust (56.4%). Nearly half of respondents also felt providers always listened actively (46.3%), gave clear explanations (51.7%), and offered emotional support (45.0%). However, shared decision-making (35.6%) and consideration of lifestyle or preferences (38.9%) were less consistent, with 16.8% saying their preferences were never considered. These results suggest that while provider–patient interactions are generally respectful and supportive, greater effort is needed to personalize communication and involve patients more in decision-making.

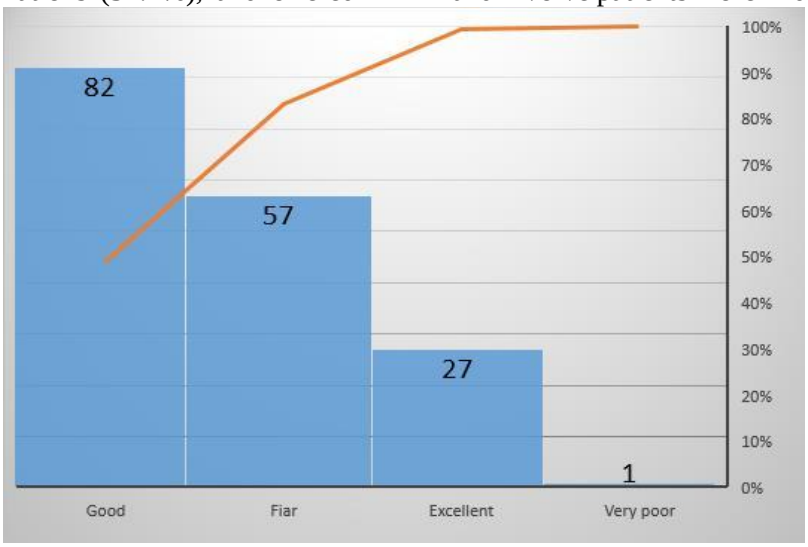


**Figure 2.** Patients Rating of the Quality of Provider Patient Communication Interactions

Figure 2 illustrates clients' overall assessment of quality of provider patient communication interaction. A majority rated their interactions to be good (55%) or Very Good (18.1%), reflecting generally positive perceptions. However, 26.2% rated it as Poor, and 0.7% as Very Poor, indicating that a notable group still experienced unsatisfactory communication interactions. While overall ratings are favorable, these findings highlight the need to improve on the interactions.

**Table 6.** Summary Score of Provider-Patient Communication Interactions

| Answer Option | Frequency of Responses | Percentage (%) |
|---|---|---|
| Never | 111 | 5.6% |
| Rarely | 103 | 5.1% |
| Sometimes | 323 | 16.2% |
| Often | 336 | 17.0% |
| Always | 766 | 38.5% |
| **Total** | **1,639** | **100%** |
| | Mean score | **3.94** |
| | Median score | **4.00** |
| | Standard deviation | **1.23** |

Table 6 summarizes patient responses across 11 key indicators of provider–patient communication interaction. The majority of responses fell under "Always" (38.5%) and "Often" (17.0%), indicating that most patients perceived their interactions with healthcare providers as consistently positive. However, 16.2% of responses were rated "Sometimes," reflecting partial or inconsistent communication experiences. A smaller percentage of patients selected "Rarely" (5.1%) or "Never" (5.6%), suggesting occasional lapses in effective engagement.

The mean score of 3.94 places the overall experience just below "Often," indicating that provider–patient communication behaviors were generally positive but not consistently high across all encounters. The median score of 4.00 ("Often") confirms that more than half of patients reported frequent positive interactions, such as empathy, active listening, and clear explanations. The standard deviation of 1.23, being above 1.0, suggests moderate variability, meaning that while most patients experienced strong interactions, some faced irregular or weaker communication quality. These findings point to a broadly effective provider–patient interaction, yet highlight the need to improve consistency in emotional support, trust-building, and shared decision-making.

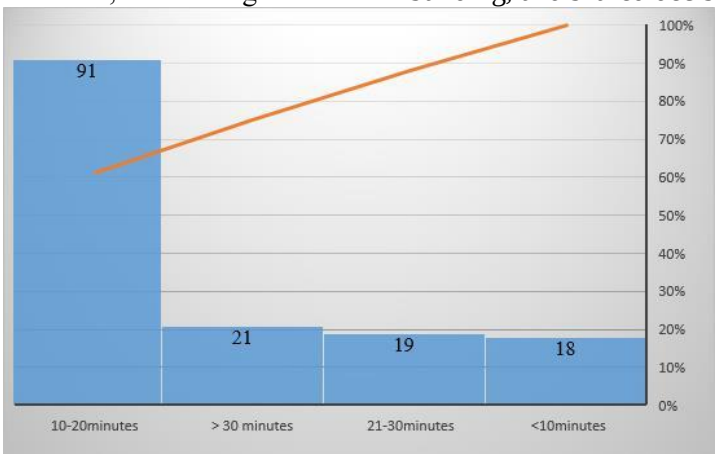


**Figure 3.** Duration of Consultation Sessions

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The figure 3 indicates that most clients (61.1%) typically spend 10–20 minutes in consultation, making it the most common duration. A smaller proportion, 12.1%, reported consultations lasting less than 10 minutes, while 14.1% experienced sessions longer than 30 minutes. This variability in consultation time may influence communication quality and overall patient satisfaction.

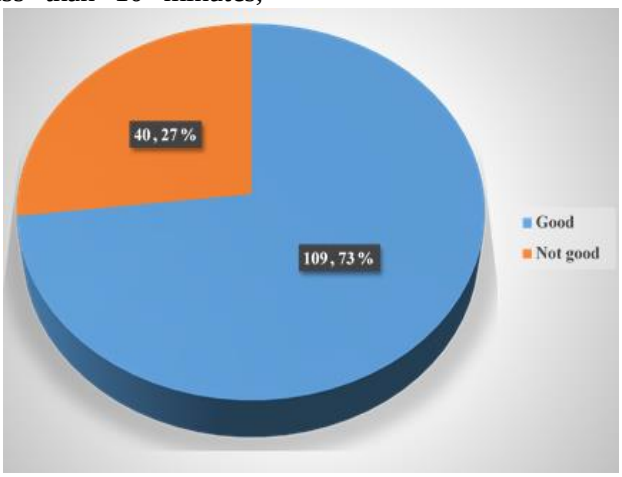


**Figure 4.** Clients Rating of the Quality of Communication (Practices and Interactions)

The pie chart as seen in figure 4 above shows that 73% of clients rated the quality of communication practices and interactions as good, while 27% rated it as not good. This indicates that most patients viewed provider communication as clear, respectful, and supportive. However, the quarter of clients who rated it negatively point to the need for improved consistency and greater focus on patient centered communication.

## Constraints to Effective Communication

This section presents the challenges that make communication between patients and healthcare providers less effective, focusing on issues like language barriers, limited consultation time, and patients' fear of asking questions, all of which can prevent them from fully understanding their condition or being actively involved in their care.

**Table 7.** Frequency Distribution of Constraints of Effective Communication

| No. | Variable | Never | Rarely | Sometimes | Often | Always |
|---|---|---|---|---|---|---|
| 1 | Language differences | 107 (71.8%) | 19 (12.8%) | 13 (8.7%) | 3 (2.0%) | 7 (4.7%) |
| 2 | Information was too complex | 74 (49.7%) | 29 (19.5%) | 34 (22.8%) | 3 (2.0%) | 9 (6.0%) |
| 3 | Provider rushed due to lack of time | 75 (50.3%) | 18 (12.1%) | 36 (24.2%) | 8 (5.4%) | 12 (8.1%) |
| 4 | Cultural differences | 110 (73.8%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |
| 5 | Lack of technological resources | 69 (46.3%) | 24 (16.1%) | 17 (11.4%) | 6 (4.0%) | 33 (22.1%) |
| 6 | Provider's communication style | 77 (51.7%) | 20 (13.4%) | 33 (22.1%) | 6 (4.0%) | 13 (8.7%) |
| 7 | Emotional concerns | 68 (45.6%) | 32 (21.5%) | 31 (20.8%) | 5 (3.4%) | 13 (8.7%) |
| 8 | Too much information | 61 (40.9%) | 17 (11.4%) | 58 (38.9%) | 5 (3.4%) | 8 (5.4%) |
| 9 | Lack of trust in provider | 83 (55.7%) | 19 (12.8%) | 23 (15.4%) | 13 (8.7%) | 11 (7.4%) |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10 | Physical and structural barriers | 65 (43.6%) | 27 (18.1%) | 21 (14.1%) | 7 (4.7%) | 29 (19.5%) |
| 11 | Educational level considered | 94 (63.1%) | 18 (12.1%) | 15 (10.1%) | 6 (4.0%) | 16 (10.7%) |

Table 7 shows that most clients did not report language (71.8%) or cultural differences (73.8%) as barriers. However, some challenges were noted. Nearly half of the clients found information too complex, and 8.1% said their provider was always rushed. Technological limitations (22.1%) and physical or structural barriers (19.5%) were also frequent concerns. A smaller portion of clients reported issues with communication style (8.7%), emotional concerns (8.7%), and too much information (5.4%), while 7.4% cited lack of trust in providers. Additionally, 10.7% felt their educational level was not always considered. These findings suggest that while communication was effective for most, barriers related to clarity, provider time, and support tools still affect a notable minority.

**Table 8.** Summary Score for Constraints to Effective Communication

| **Answer Option** | **Frequency of Responses** | **Percentage (%)** |
|---|---|---|
| Never | 794 | 50.6% |
| Rarely | 157 | 10.2% |
| Sometimes | 336 | 21.8% |
| Often | 85 | 5.5% |
| Always | 184 | 12.0% |
| **Total** | **1,556** | **100%** |
| | Mean score | **2.17** |
| | Median score | **1.00** |
| | Standard deviation | **1,41** |

Table 8 summarizes patients' cumulative responses across 11 variables measuring constraints to effective communication. A majority of responses (50.6%) were rated "Never," suggesting that most patients did not experience communication barriers. An additional 10.2% indicated "Rarely," pointing to occasional but manageable challenges. However, 21.8% of responses were marked "Sometimes," reflecting intermittent communication difficulties.

Notably, 12.0% of respondents "Always" and 5.5% "Often" experienced communication barriers, suggesting that a subset of patients regularly encounters obstacles such as language issues, emotional discomfort, or provider-related limitations.

The mean score of 2.17 indicates that, on average, patients experienced communication constraints between "Rarely" and "Sometimes," suggesting that such barriers were not frequent but still present in many encounters. The median score of 1.00 ("Never") shows that at least half of the respondents reported no barriers at all, pointing to a generally positive experience in terms of communication flow. However, the standard deviation of 1.41, being greater than 1.0, reflects moderate variability, meaning that while many patients experienced smooth communication, a considerable number encountered inconsistent or recurrent obstacles. This mixed pattern suggests a need to strengthen consistency in communication experiences across all patient groups.

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## Relationship between Communication Practices and Patient Perception of Quality of Communication

This section tested Hypothesis 1, which examined whether better communication practices, such as using simple language, offering emotional support, or involving patients in decision-making, are related to patients' perception of communication quality. Pearson's correlation was used because it measures the strength and direction of the relationship between each communication practice and patients' overall perception (categorized as "good" or "not good"). It was appropriate for identifying whether improvements in communication practices were associated with better-rated communication. Results were considered statistically significant when the p-value was less than 0.05.

**Table 9.** Correlation between Communication Practices and Quality of Communication (n=149)

| SN | Communication Practices | Quality of communication (good/ not good) (r) | p-value |
|---|---|---|---|
| 1 | Provider explains using simple language | 0.159 | 0.052 |
| 2 | Provider uses pictures, diagrams | **0.24** | **0.003** |
| 3 | Handouts given | 0.087 | 0.294 |
| 4 | Handouts easy to understand | 0.054 | 0.51 |
| 5 | Provider asks you to explain back | 0.136 | 0.097 |
| 6 | Clear instructions after visit | **0.218** | **0.008** |
| 7 | Provider considers feelings and concerns | **0.344** | **0** |
| 8 | Provider communicates to fit culture | **0.198** | **0.016** |
| 9 | Provider considers educational level | 0.058 | 0.482 |
| 10 | Enough chances to ask questions | **0.295** | **0** |
| 11 | Explanation helps you manage diabetes | **0.214** | **0.009** |
| 12 | Provider encourages better self-care | **0.262** | **0.001** |
| 13 | Receive regular updates | **0.407** | **0** |

The results in Table 9 reveal that most communication practices were positively associated with patients' perception of communication quality, although the strength and significance of these relationships varied. The strongest correlation was for receiving regular updates from providers ($r = 0.407$, $p < 0.001$). This is a moderate and statistically significant relationship, meaning that patients who consistently received follow-up updates were more likely to perceive communication as effective.

This was followed by providers considering patients' feelings and concerns ($r = 0.344$, $p < 0.001$) and giving enough opportunities to ask questions ($r = 0.295$, $p < 0.001$)—both moderately strong correlations, suggesting that when patients feel heard and involved, they rate communication more positively. In other words, the more patients felt emotionally supported and able to participate, the better they judged the quality of communication.

Other communication elements that showed statistically significant positive correlations included the use of visual aids such as pictures or diagrams ($r = 0.240$, $p = 0.003$), giving clear instructions after visits ($r = 0.218$, $p = 0.008$), tailoring communication to the patient's cultural background ($r = 0.198$, $p = 0.016$), explanations that help patients manage their diabetes better ($r = 0.214$, $p = 0.009$), and encouraging better self-care ($r = 0.262$, $p = 0.001$). Although these associations were moderate, they all showed that better application of these practices tends to enhance patients' evaluation of communication quality.

These findings mean that the more these practices are used—especially those involving empathy, feedback, and practical tools— the better patients rated the quality of communication.

In contrast, certain practices showed weak and statistically non-significant relationships with perceived communication quality. These included giving handouts (r = 0.087, *p* = 0.294), making handouts easy to understand (r = 0.054, *p* = 0.510), and considering patients' educational level (r = 0.058, *p* = 0.482). These results suggest that these components, while potentially useful, did not play a substantial role in influencing how patients judged the quality of communication in this context.

The overall trend was that stronger interpersonal engagement, follow-up, clarity, and emotional sensitivity from providers significantly improved patients' perception of communication. These findings support the hypothesis that effective communication practices play a crucial role in enhancing the quality of communication in diabetes care.

## Influence of Provider-patient Interaction on Perception Quality on Communication

This section tested Hypothesis 2, which explored whether provider–patient interaction, such as listening, empathy, and time spent, affects how patients perceive the quality of communication. A one-way ANOVA was used because it helps compare the mean perception scores across different response levels (e.g., from "Never" to "Always") for each interaction behavior. This test was appropriate since it allowed assessment of whether differences in communication behavior led to significant changes in patients' ratings. A p-value below 0.05 indicated a significant effect, and higher F-values reflected stronger influence of specific behaviors on patient perception.

**Table 10.** One Way Anova Results of Provider-patient Communication Interactions on Quality of Communication

| Sn | Variable | Source | Sum of Squares | Df | Mean Square | F | pvalue |
|---|---|---|---|---|---|---|---|
| 1 | Provider gives time to talk | Between | 5.747 | 4 | 1.437 | 8.798 | **0** |
| | | Within | 23.515 | 144 | 0.163 | | |
| 2 | Provider listens carefully | Between | 6.545 | 4 | 1.636 | 10.373 | **0** |
| | | Within | 22.716 | 144 | 0.158 | | |
| 3 | Provider treats with kindness/ respect | Between | 2.89 | 4 | 0.722 | 3.945 | **0.005** |
| | | Within | 26.372 | 144 | 0.183 | | |
| 4 | Provider involves in decision-making | Between | 5.698 | 4 | 1.424 | 8.705 | **0** |
| | | Within | 23.564 | 144 | 0.164 | | |
| 5 | Comfort sharing personal information | Between | 4.344 | 4 | 1.086 | 6.276 | **0** |
| | | Within | 24.918 | 144 | 0.173 | | |
| 6 | Provider shows compassion | Between | 7.476 | 4 | 1.869 | 12.353 | **0** |
| | | Within | 21.786 | 144 | 0.151 | | |
| 7 | Provider explains options clearly | Between | 4.819 | 4 | 1.205 | 7.098 | **0** |
| | | Within | 24.442 | 144 | 0.17 | | |
| 8 | Provider respects privacy | Between | 1.305 | 4 | 0.326 | 1.681 | 0.158 |
| | | Within | 27.957 | 144 | 0.194 | | |
| 9 | Trust in provider | Between | 6.965 | 4 | 1.741 | 11.246 | **0** |
| | | Within | 22.296 | | 0.155 | | |
| 10 | Suggestions fit lifestyle | Between | 8.84 | 4 | 2.21 | 15.583 | **0** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Within n | 20.422 | 1444 | 0.142 | | |
| 11 | Emotional support during visits | Between | 7.732 | 4 | 1.933 | 12.93 | **0** |
| | | Within | 21.529 | 1444 | 0.15 | | |
| 12 | Provider considers education level | Between | 3.643 | 3 | 1.214 | 6.873 | **0** |
| | | Within | 25.619 | 145 | 0.177 | | |

The one-way ANOVA results on table 10 above show that several providers–patient communication interactions or behaviors had a significant influence on how clients perceived the overall quality of communication. Notably, when providers listened attentively ($F = 10.373$, $p < 0.001$), showed compassion ($F = 12.353$, $p < 0.001$), gave emotional support ($F = 12.930$, $p < 0.001$), and tailored their suggestions to the patient's lifestyle ($F = 15.583$, $p < 0.001$), patients were more likely to rate communication quality as high. Similarly, clear explanation of options, involvement in decision-making, trust in the provider, and allowing enough time during consultations also showed significant positive effects.

However, privacy was the only area that did not show a significant difference ($p = 0.158$), which may indicate that it was generally not considered by patients well maintained across the board. Overall, the findings highlight that respectful, empathetic, and patient-centered behaviors play a key role in how patients evaluate the quality of communication with their healthcare providers.

## Influence of Communication Constraints on Patient Perception of Quality of Communication

This section examines Hypothesis 3, which tested whether specific communication barriers influence how patients rate the quality of communication with their healthcare providers. A linear regression was used to analyze the effect of 11 communication constraints on patient rated communication quality (categorized as "good" or "not good"). This method was chosen because it allows us to measure how each barrier independently contributes to changes in the outcome. Significance was determined using p-values (with $p < 0.05$ considered statistically significant) and standardized Beta values, which show the strength and direction of the relationship. This helped identify the most impactful barriers affecting patients' perception of communication.

**Table 11.** Linear Regression Results of Constraints of Communication on Quality of Communication

| SN | Communication Constraint | B-Unstandardized | Std. Error | Beta (Standardized) | t-value | p value |
|---|---|---|---|---|---|---|
| 1 | Language differences | 0.009 | 0.029 | 0.022 | 0.325 | 0.746 |
| 2 | Information was too complex | 0.042 | 0.039 | 0.110 | 1.089 | 0.278 |
| 3 | **Provider rushed (lack of time)** | **-0.136** | **0.032** | **-0.398** | **-4.302** | **0.000** |
| 4 | Cultural differences | 0.041 | 0.035 | 0.091 | 1.165 | 0.246 |
| 5 | **Lack of technological tools** | **-0.059** | **0.020** | **-0.212** | **-2.941** | **0.004** |
| 6 | Provider's communication style | -0.056 | 0.035 | -0.163 | -1.610 | 0.110 |
| 7 | Emotional concerns | 0.014 | 0.030 | 0.039 | 0.454 | 0.651 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8 | **Too much information** | **-0.065** | **0.032** | **-0.173** | **-2.014** | **0.046** |
| 9 | Lack of trust in provider | -0.031 | 0.032 | -0.093 | -0.991 | 0.323 |
| 10 | Physical and structural barriers | 0.022 | 0.028 | 0.077 | 0.777 | 0.438 |
| 11 | **Consideration of educational level** | **-0.054** | **0.023** | **-0.165** | **-2.387** | **0.018** |

The regression results on table 11 revealed that several communication constraints had a statistically significant negative impact on how patients rated the quality of communication. Notably, the perception that the provider was rushed or lacked time (B = -0.136, $p$ = 0.000) was the strongest negative predictor, followed by lack of access to technological tools (B = -0.059, $p$ = 0.004), excessive or overwhelming information during consultations (B = -0.065, $p$ = 0.046), and lack of consideration for the patient's educational level (B = -0.054, $p$ = 0.018). These findings suggest that when communication is hurried, poorly supported, or not adapted to the patient's level of understanding, it significantly reduces their perception of communication quality.

On the other hand, barriers such as language differences, cultural misunderstandings, emotional concerns, and trust issues did not show statistically significant associations (p > 0.05), indicating that they may have had less direct influence within this study population. Overall, the model supports the hypothesis that practical and structural communication challenges particularly those related to time, clarity, and personalization are key determinants of how patients evaluate the quality of communication they receive in diabetes care.

## Influence Of Sociodemographic and Care-Related Factors on Patient Satisfaction

This section tested Hypothesis 4 by examining whether factors like age, gender, education, and treatment experience influenced how patients rated the quality of communication with their healthcare providers. A multiple linear regression was used because it helps assess the effect of several factors at once. Results were considered significant if $p < 0.05$, and $t$-values showed how strongly each factor influenced communication ratings.

**Table 12.** Linear Regression Distribution of Sociodemographic and Clinical Characteristics of Patients and Quality of Communication

| SN | Independent Variable | Unstandardized Coefficient (B) | Std. Error | Standardized Coefficient (Beta) | t-value | p-value |
|---|---|---|---|---|---|---|
| 1. | Age category | -0.065 | 0.065 | -0.095 | -0.997 | 0.321 |
| 2. | Gender | -0.018 | 0.083 | -0.019 | -0.216 | 0.830 |
| 3. | Level of education | 0.036 | 0.033 | 0.098 | 1.086 | 0.279 |
| 4. | Duration of care | 0.037 | 0.070 | 0.050 | 0.526 | 0.600 |
| 5. | Type of treatment | -0.102 | 0.060 | -0.147 | -1.702 | 0.091 |
| 6. | Frequency of care | -0.049 | 0.057 | -0.074 | -0.870 | 0.386 |

As presented in Table 12, none of the variables showed a statistically significant association with the perceived quality of communication. For instance, age ($p$ = 0.321), gender ($p$ = 0.830), and education level ($p$ = 0.279) had no significant effects. Similarly, duration of care ($p$ = 0.600), type of treatment ($p$ = 0.091), and frequency of care ($p$ = 0.386) also did not significantly predict patient ratings of communication quality.

These findings suggest that patients' perceptions of how well providers communicate are not influenced by their demographic background or treatment characteristics. Instead, the quality of communication appears to depend more on the communication behaviors of the providers themselves. Therefore, Hypothesis 4 was not supported in this study.

## Multiple Regression Analysis: Predictors of Patient Perception of Quality of Communication

This section presents a multiple linear regression analysis used to identify which communication behaviors significantly influence patients' perception of communication quality. The dependent variable was whether communication was rated as "good" or "not good." The 24 predictors included only those variables that were significant in earlier individual tests.

This method was chosen because it examines all predictors together while controlling for confounding effects, allowing us to see which factors independently affect patient perception. Significance was set at $p < 0.05$.

**Table 13.** Multiple Regression Results of all Significant Variables and Quality of Communication

| SN | Communication Variable | B (Unstandardized) | Std. Error | t-value | p-value |
|---|---|---|---|---|---|
| 1 | Provider explains using simple language | 0.016 | 0.034 | 0.473 | 0.637 |
| 2 | Provider uses pictures/diagrams | 0.050 | 0.023 | 2.198 | 0.030** |
| 3 | Clear instructions after visit | -0.017 | 0.028 | -0.603 | 0.548 |
| 4 | Provider considers feelings, concerns | 0.003 | 0.037 | 0.086 | 0.931 |
| 5 | Provider communicates to fit culture | 0.016 | 0.031 | 0.524 | 0.601 |
| 6 | Chances to ask questions | 0.003 | 0.032 | 0.090 | 0.928 |
| 7 | Explanation helps manage diabetes | -0.001 | 0.043 | -0.012 | 0.990 |
| 8 | Provider encourages self-care | 0.045 | 0.032 | 1.419 | 0.158 |
| 9 | Receive regular updates | -0.009 | 0.024 | -0.372 | 0.711 |
| 10 | Gives time to talk and share concerns | -0.036 | 0.040 | -0.910 | 0.365 |
| 11 | Listens carefully without interruption | 0.053 | 0.041 | 1.283 | 0.202 |
| 12 | Treats with kindness and respect | -0.063 | 0.033 | -1.940 | 0.055 |

| | | | | | |
|---|---|---|---|---|---|
| 13 | Involves you in decision-making | 0.051 | 0.026 | 1.962 | 0.052 |
| 14 | Comfortable sharing personal info | -0.022 | 0.028 | -0.797 | 0.427 |
| 15 | Shows understanding and compassion | 0.069 | 0.038 | 1.815 | 0.072 |
| 16 | Explains options & helps choose best | -0.003 | 0.028 | -0.103 | 0.918 |
| 17 | Trust in provider | 0.017 | 0.038 | 0.436 | 0.664 |
| 18 | Suggestions fit lifestyle | -0.039 | 0.033 | -1.179 | 0.241 |
| 19 | Supports you emotionally | 0.049 | 0.037 | 1.313 | 0.192 |
| 20 | Duration of consultation | 0.087 | 0.035 | 2.495 | 0.014 |
| 21 | Provider rushed / lack of time | -0.081 | 0.031 | -2.663 | 0.009 |
| 22 | Lack of technological style | -0.028 | 0.021 | -1.324 | 0.188 |
| 23 | Too much information | -0.086 | 0.032 | -2.717 | 0.008 |
| 24 | Considers educational level | -0.042 | 0.025 | -1.718 | 0.088 |

The multiple regression analysis on table 13 revealed that out of the 24 communication-related variables tested, four were statistically significant predictors of how patients rated the overall quality of communication. The use of pictures or diagrams had a positive effect ($B$ = 0.050, $p$ = 0.030), suggesting that visual aids help improve patients' understanding and overall perception of good communication. Longer consultation time was also a significant positive factor ($B$ = 0.087, $p$ = 0.014), indicating that when providers spend more time with patients, communication is perceived more positively.

On the other hand, two variables negatively influenced communication quality. Patients who felt providers were rushed ($B$ = -0.081, $p$ = 0.009) or overwhelmed with too much information ($B$ = -0.086, $p$ = 0.008) were less likely to rate communication as good. This highlights the importance of pacing communication and ensuring patients are not overloaded.

Although some factors like provider kindness and patient involvement in decisions came close to significance, they did not meet the $p < 0.05$ threshold in the full model. Overall, the results suggest that time, clarity, and the appropriate use of visual aids are crucial for enhancing communication quality, even when controlling for other communication practices, interactions, and constraints.

## Discussion

The results indicate that most participants were older adults, with an average age of 61.29 years, and the majority had been living with diabetes for more than two years. This reflects a population largely engaged in long-term disease management, which is typical of ageing groups. This finding is consistent with recent evidence from the North West Region of Cameroon where diabetes care utilization was highest among older adults with long-standing disease, reflecting the chronic nature of diabetes and the need for continuous engagement with healthcare services [3]. Comparable patterns have been observed in Cameroon and other parts of sub-Saharan Africa, where the prevalence of diabetes tends

to rise with age due to prolonged exposure to behavioral and metabolic risk factors [2, 14]. The predominance of female participants aligns with findings from studies conducted in Ghana and Nigeria, where women are generally more likely to utilize healthcare services and maintain regular follow-up [15, 16]. These observations highlight the need to tailor communication approaches to older individuals, many of whom may also have limited formal education.

Findings from this study also show that communication practices were moderately effective. Patients commonly reported that healthcare providers used simple language and delivered explanations that were easy to understand, suggesting that verbal interaction remains the primary mode of communication in this setting. Similar observations have been reported in South Africa, where clear explanations are considered essential for managing chronic conditions [17]. These findings are consistent with recent recommendations emphasizing health literacy-sensitive communication approaches that adapt information to patients' comprehension levels and cultural context. [18]. Despite this strength, notable gaps were identified, particularly the limited use of visual aids, written materials, and digital tools. Comparable challenges have been documented in Ethiopia and Kenya, where communication often relies heavily on verbal exchange due to resource constraints and the absence of structured educational materials [19, 20]. New studies indicate that visual educational materials improve patient understanding, recall of information, and diabetes self-management, particularly among populations with limited literacy skills [21]. Emerging evidence indicates that incorporating visual and digital support tools can enhance patient understanding and participation, especially among individuals with low health literacy [22, 23].

The statistical analysis further reinforces these findings. Communication elements such as regular follow-up, emotional support, and opportunities for patient questions showed significant associations with better perceived communication quality. This points to the fact that the effectiveness of communication is shaped not only by how clearly information is presented but also by how actively patients are engaged during consultations. Comparable evidence from South Africa demonstrates that sustained interaction and patient involvement are linked to improved health outcomes [24]. In addition, regression results revealed that the use of visual aids contributed positively to communication quality, whereas providing excessive information had a negative effect. This emphasizes the importance of structuring communication in a way that aligns with patients' level of understanding. Studies from Uganda and Tanzania similarly report that simplified and structured communication approaches, including the use of visual tools, improve comprehension and support better self-management among patients with chronic conditions [25].

The results related to provider–patient interaction show that many patients experienced positive relationships with healthcare providers, particularly in areas such as respect, empathy, trust, and privacy. These elements reflect strong interpersonal communication and are consistent with the principles of patient-centered care. Comparable findings have been reported in Ghana, where respectful engagement and trust were identified as major contributors to patient satisfaction [26]. However, aspects such as shared decision-making and the integration of patients' daily realities into care were less consistently observed, suggesting that clinical interactions still tend to be driven largely by providers. Current evidence suggests that shared decision-making remains one of the strongest predictors of patient satisfaction and long-term adherence among people living with chronic diseases [27] This pattern has also been described in Cameroon and other African settings, where

hierarchical structures in healthcare can limit active patient participation in decision-making processes [28, 29].

Further statistical analysis strengthens the importance of interaction quality in shaping patient perceptions. The ANOVA results demonstrated that behaviors such as attentive listening, compassion, emotional support, and involving patients in decisions had a significant effect on how communication was perceived. This indicates that the relational aspect of care is central to patient experience. Evidence from Kenya and Tanzania similarly shows that when patients feel heard and respected, they are more likely to adhere to treatment and report better health outcomes [20, 29]. In addition, the correlation analysis revealed that providing opportunities for patients to ask questions and offering emotional support were strongly linked to improved perceptions of communication, highlighting the value of interactive and participatory approaches.

Although communication barriers were not widely reported, several important challenges emerged from the findings. These included the use of complex medical language, limited time during consultations, insufficient technological support, and communication that is not always adapted to patients' educational background. Similar barriers continue to be reported globally, particularly in resource-constrained settings where heavy patient loads limit opportunities for individualized communication and patient education [30] These challenges reflect both system-level limitations and provider-related factors. Similar constraints have been documented in Nigeria and Ethiopia, where high patient volumes and short consultation times reduce the effectiveness of communication [31, 10]. Broader evidence also indicates that time constraints and low health literacy continue to hinder effective communication in the management of chronic conditions [22].

The regression analysis provides additional insight into these challenges by identifying key factors that negatively influence communication quality. Short consultation time, excessive information delivery, and lack of technological support were all associated with poorer communication outcomes. These findings are important because they point to areas that can be improved within the health system. At the same time, longer consultation time was found to enhance communication quality, reinforcing the importance of allowing sufficient time for patient interaction. Similar observations have been reported in Tanzania and Uganda, where adequate consultation time improves patient understanding and supports better adherence to treatment [25].

It is also noteworthy that patients' sociodemographic and clinical characteristics did not significantly affect their perception of communication quality. This indicates that how providers communicate, as well as how services are organized, plays a more important role than individual patient characteristics. Alike conclusions have been drawn in studies conducted in Cameroon, where provider communication style was identified as a key determinant of patient satisfaction regardless of age, gender, or level of education [28].

Taken together, these findings point to the need for practical interventions aimed at improving communication in diabetes care. Strengthening healthcare provider training in patient-centered communication, ensuring adequate consultation time, and introducing simple supportive tools such as visual aids and teach-back methods could improve patient understanding and engagement. Further research is needed to assess the impact of these strategies and to explore how digital health solutions can be adapted effectively within low-resource settings.

## Conclusion

This study examined factors influencing the quality of health communication in diabetes care within the Bamenda Health District, focusing on communication practices,

provider–patient interaction, and existing barriers. The findings indicate that communication is generally satisfactory, particularly in the use of clear language and in maintaining respectful and supportive relationships between providers and patients. Despite these strengths, gaps persist in the use of structured communication approaches, patient participation in decision-making, and consistency in how information is delivered.

The results further show that communication quality is largely shaped by factors that can be improved at the provider and system levels. Practices such as clear explanations, emotional support, and opportunities for patient involvement were linked to better communication experiences. In contrast, limited consultation time, excessive information, and poor adaptation to patients' level of understanding negatively affected communication. The positive contribution of visual aids and adequate consultation time also highlights practical areas where improvements can be made. The absence of significant influence from sociodemographic and clinical characteristics suggests that enhancing communication practices can benefit all patients.

Improving communication in diabetes care therefore requires targeted actions, including strengthening provider skills in patient-centered communication, promoting the use of simple supportive tools, and ensuring adequate time for patient interaction. Addressing these areas can improve patient understanding, treatment adherence, and overall care outcomes.

Further research should assess the impact of structured communication approaches and digital tools in similar settings. In addition, qualitative studies are needed to explore in more depth the experiences and perspectives of both patients and healthcare providers, which will complement these findings and support the development of context-appropriate communication strategies.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

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This research did not receive any specific grant from funding agencies in the public, commercial, or non-profit sectors.

## Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

## Ethical Approval

Ethical approval for the study was obtained from ethical review board of the regional delegation of public health for the North West region Bamenda Cameroon, the appropriate institutional and administrative authorities prior to data collection. Permission to conduct the study was granted by the management of the participating health facilities. Written informed consent was obtained from all participants before enrollment, and confidentiality and anonymity were strictly maintained throughout the study. Participation was voluntary, and respondents were free to withdraw at any stage without any consequences.

## Author Contributions

Eyong Manyiyong Queenta conceived and designed the study, supervised the research process, conducted data analysis, interpreted the findings, and drafted the manuscript. Fietsop Ernestine Nkemta, Frida Bessem Taku Bate, Yuyeh Virginia Mawo, and Egbe Derick Agbor contributed to data collection, data cleaning, and manuscript revision. Bodzewan Emmanuel provided overall academic oversight and guidance. All authors reviewed and approved the final version of the manuscript.

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# Assessing Knowledge and Awareness of HIV Pre-exposure Prophylaxis (PrEP) Among University Students in Nkurenkuru Town, Namibia

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***Abstract*** *Pre-exposure prophylaxis (PrEP) is an effective biomedical strategy for preventing HIV transmission; however, its impact depends on adequate awareness, understanding, and willingness to use it, particularly among vulnerable groups such as university students. Evidence on PrEP awareness in semi-rural settings like Nkurenkuru Town, Namibia, remains limited. This cross-sectional study, conducted from January to December 2023 among 200 university students, used a structured self-administered questionnaire, with data analyzed using descriptive statistics and chi-square tests. Findings revealed low awareness, with only 25% of participants having heard of PrEP and just 10% demonstrating adequate knowledge of its use. Digital platforms (38.5%) and healthcare workers (30.5%) were the main information sources. Despite limited awareness, 72.5% of students expressed willingness to use PrEP if recommended by a healthcare professional. A significant association was found between prior awareness and willingness to use PrEP, with higher acceptance among those aware of it (90.0%) compared to those unaware (66.7%) ($\chi^2=13.67$, $p=0.008$). Although better knowledge was associated with greater willingness (90.0% vs. 70.6%), this was not statistically significant ($\chi^2=3.41$, $p=0.065$). Overall, while willingness to use PrEP is high, awareness and knowledge remain insufficient, highlighting the need for targeted educational interventions and increased involvement of healthcare providers to improve uptake among university students.*

***Keywords*** *Awareness and Knowledge, HIV Prevention, Namibia, PrEP, Student Population.*

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## Introduction

Pre-exposure prophylaxis (PrEP) is widely recognized as a key biomedical strategy for preventing HIV infection and has proven highly effective when taken consistently by individuals who are HIV-negative but at elevated risk. Nevertheless, the overall public health benefit of PrEP depends largely on levels of awareness, depth of understanding, and accessibility of youth-friendly prevention services. Namibia continues to face a generalized HIV epidemic, with adult prevalence estimated at approximately 12.6%, alongside notable regional differences. In the Kavango West Region, prevalence remains similarly high at around 12.1%, according to findings from the 2017 Namibia Population-Based HIV Impact Assessment (NAMPHIA) [37-40]. Within this setting, strengthening prevention strategies that effectively engage young people, particularly in semi-rural communities, remains a critical priority for public health efforts [1].

University students constitute a particularly important group for HIV prevention initiatives due to their increasing independence, expanding social networks, and greater likelihood of engaging in new sexual relationships, which may elevate exposure to HIV risk. Despite the expanding availability of PrEP services across Namibia, studies from southern Africa consistently report that uptake among university students remains suboptimal. This is often attributed to limited awareness, persistent misconceptions, stigma, and irregular interaction with healthcare services [2, 3, 15, 16]. Although global and regional research on PrEP has grown substantially, there is still a lack of context-specific evidence regarding awareness, knowledge, and attitudes among students in semi-rural environments such as Nkurenkuru, where access to prevention information and services may be less consistent than in urban areas [29].

In response to these gaps, the present study evaluated the level of awareness and knowledge of HIV pre-exposure prophylaxis among university students in Nkurenkuru Town, Namibia. It further examined the primary sources of PrEP-related information and assessed students' willingness to use PrEP. Additionally, the study explored the relationship between awareness and willingness to use PrEP, while also incorporating qualitative insights to better understand perceived barriers and enabling factors influencing PrEP acceptability within this population.

### Purpose

This study was undertaken to evaluate the level of knowledge and awareness of HIV pre-exposure prophylaxis (PrEP) among university students in Nkurenkuru Town, Namibia. It specifically seeks to identify knowledge gaps, misconceptions, and informational deficiencies within this population. By doing so, the study aims to generate evidence that can guide the development of targeted educational interventions and awareness campaigns to promote the effective use of PrEP as a preventive strategy against HIV transmission.

### Significance

Assessing PrEP-related knowledge among university students is of considerable importance for several reasons. University students represent a population that may be at increased risk of HIV infection due to evolving social behaviors, increased independence, and potential engagement in high-risk sexual practices. Improving awareness and understanding of PrEP within this group has the potential to reduce new HIV infections both among students and within the wider community. Furthermore, the findings of this study can support policymakers and public health practitioners in designing context-specific programs aimed at improving access to, and uptake of, PrEP services among young adults in Namibia.

## Aim

The primary aim of this study was to assess the level of awareness and knowledge of HIV pre-exposure prophylaxis (PrEP) among university students in Nkurenkuru Town, Namibia.

## Objectives

1. To evaluate students' general knowledge of HIV transmission and prevention strategies.
2. To determine the level of awareness and understanding of PrEP among university students.
3. To identify common misconceptions and perceived barriers that may influence PrEP awareness and potential utilization.
4. To examine the main sources through which students obtain information about HIV and PrEP.
5. To assess the relationship between PrEP knowledge and willingness to use PrEP.

## Knowledge and Awareness of HIV and PrEP

Understanding the level of PrEP knowledge among university students requires consideration of evidence from similar settings. Studies conducted across Africa consistently indicate that while general knowledge of HIV transmission is relatively high among students, awareness and understanding of PrEP remain limited [5–13]. For example, research conducted in Namibia found that although students demonstrated adequate knowledge of HIV prevention, awareness of PrEP was insufficient, highlighting the need for focused educational interventions [2].

Comparable findings have been reported in South Africa, where university students exhibited moderate understanding of HIV prevention but limited familiarity with PrEP [3]. Additional cross-sectional studies have shown that awareness levels can be as low as 22%, further emphasizing the need for targeted educational strategies aimed at young populations [14].

Globally, systematic reviews have identified several barriers to PrEP uptake among university students, including limited awareness, stigma, concerns about potential side effects, and structural challenges such as cost and access to services [15]. A scoping review focusing on southern Africa similarly reported widespread knowledge gaps and emphasized the urgent need for context-specific educational programs tailored to university populations [16].

Evidence from Europe [18] and other high-income regions also demonstrates low levels of PrEP awareness, indicating that knowledge gaps are not limited to low- and middle-income settings [17]. These findings collectively suggest that increasing awareness and correcting misconceptions are essential steps toward improving PrEP uptake.

Studies conducted specifically in Nkurenkuru and similar contexts contexts [23] further reinforce these concerns. Previous research in the region has identified substantial gaps in knowledge, persistent misconceptions, and concerns related to PrEP effectiveness and side effects [19–22]. At the same time, evidence suggests that targeted awareness campaigns can significantly improve knowledge levels among students [20].

Research from other regions, including the United States, Australia, and Nigeria, consistently reports low awareness of PrEP among university students, often linked to inadequate sexual health education and limited exposure to HIV prevention information [24–26]. These findings highlight the global nature of the problem and the importance of strengthening education and communication strategies.

## Knowledge, Awareness, and Barriers to PrEP Uptake

Existing literature indicates that limited awareness and insufficient knowledge remain

key obstacles to PrEP utilization among young adults. Studies have shown that uptake is strongly influenced by awareness levels, healthcare provider engagement, and accessibility of services [24]. Additionally, barriers such as stigma, fear of side effects, and low perceived risk of HIV infection continue to hinder adoption, while facilitators include accurate information and strong healthcare support systems [25].

In sub-Saharan Africa, willingness to use PrEP is often high despite low awareness. For instance, studies in Nigeria have demonstrated that individuals may be willing to use PrEP when adequately informed, suggesting that improving knowledge could significantly enhance uptake [26]. International guidelines from the World Health Organization and UNAIDS further emphasize the importance of integrating PrEP into comprehensive HIV prevention strategies, particularly for high-risk populations [27, 28].

Among university students in Africa, similar patterns have been observed. Research in Uganda reported low knowledge but generally positive attitudes toward PrEP, with stigma and misinformation identified as major barriers [29]. Additional studies have highlighted the role of social perceptions and fear of discrimination in limiting PrEP use among young people [30].

The growing influence of digital media digital media [32] has also transformed how students access health information. While online platforms can improve awareness, they may also contribute to misinformation if not properly regulated [31]. This underscores the need for accurate, evidence-based digital communication strategies.

Overall, the literature demonstrates a consistent pattern: while willingness to use PrEP is relatively high, inadequate knowledge, stigma, and inconsistent information sources continue to limit effective uptake.

### Sources of Information on HIV and PrEP

Understanding the sources of information that university students rely on for HIV and PrEP-related knowledge is crucial for effective educational interventions. Shikwambi and Strode found that the internet and health professionals were the primary sources of information for students in Namibia [2]. Conversely, a study by Peltzer and Pengpid in South Africa revealed that university students relied heavily on peers and friends for HIV-related information [3].

This highlights the need for targeted interventions that utilize multiple channels, including online platforms, health professionals, and peer education programs, to disseminate accurate and comprehensive information about HIV and PrEP to university students in Nkurenkuru Town.

## Materials and Methods

A cross-sectional mixed-methods study was conducted in Nkurenkuru Town, Namibia, between January and December 2023. The study incorporated both quantitative and qualitative approaches to provide a comprehensive understanding of PrEP awareness, knowledge, and perceptions.

Quantitative data were collected using a structured, self-administered questionnaire that captured socio-demographic characteristics, awareness and knowledge of PrEP, sources of information, and willingness to use PrEP. Qualitative data was obtained through focus group discussions guided by a semi-structured interview tool designed to explore perceptions, stigma, and barriers or facilitators influencing PrEP uptake.

Data analysis was performed using SPSS version 26.0. Descriptive statistics, including proportions and 95% confidence intervals, were generated, and chi-square tests were used to assess associations between variables. Statistical significance was set at $p < 0.05$.

Qualitative data was analyzed using thematic analysis to identify key patterns and themes.

The sample size was calculated using the single population proportion formula, assuming a 25% awareness level, 95% confidence interval, and 5% margin of error. After applying finite population correction [35] and adjusting for a 10% non-response rate, the final target sample size was 205 participants. Due to logistical considerations, 200 students were included in the study using a convenience sampling approach.

Ethical approval was obtained from the relevant ethics committee, and informed consent was secured from all participants. Confidentiality and anonymity were maintained throughout the study.

## Study Design and Sampling Procedure

This study employed a cross-sectional design and utilized both quantitative and qualitative approaches to assess knowledge, awareness, and perceptions of HIV Pre-Exposure Prophylaxis (PrEP) among university students in Nkurenkuru Town, Namibia.

## Study Population and Sampling Frame

The study population comprised registered university students enrolled in institutions located in Nkurenkuru Town during the 2023 academic year. In consultation with university administrations, enrolment records indicated an estimated total student population of approximately 500 students across different faculties.

## Sample Size Determination

The sample size for the quantitative component was calculated using the single population proportion formula, which is widely recommended for cross-sectional studies assessing prevalence or awareness levels [1, 2]:

$$n_0 = \frac{Z^2 \times p(1-p)}{d^2}$$

Where Z = 1.96 corresponds to a 95% confidence level, p = 0.25 represents the expected proportion of students aware of PrEP based on preliminary findings, and d = 0.05 is the margin of error.

Substituting these values:

$$n_0 = \frac{(1.96)^2 \times 0.25 \times 0.75}{(0.05)^2}$$

$$n_0 = \frac{3.8416 \times 0.1875}{0.0025} = 288.12 \approx 289$$

Given that the total student population was relatively small (N = 500), a finite population correction [35] (FPC) was applied to adjust the sample size, as recommended when the study population is less than 10,000 [33, 34]:

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

$$n = \frac{289}{1 + \frac{288}{500}} = \frac{289}{1.576} = 183.4 \approx 184$$

To account for a potential 10% non-response rate, which is standard practice in survey-based studies [4], the final adjusted sample size was calculated as:

$$n = \frac{184}{0.90} = 204.4 \approx 205$$

Accordingly, a target sample size of 205 students was proposed. Due to feasibility considerations, a total of 200 students were ultimately recruited and included in the analysis, which is comparable to the calculated sample size and considered adequate for achieving the study objectives [36].

## Sampling Technique

Participants were selected using a convenience sampling technique, with proportional representation from different faculties where feasible.

Quantitative data was collected using a structured, self-administered questionnaire. Qualitative data were obtained through focus group discussions (FGDs) using a semi-structured discussion guide to explore students' awareness of PrEP, perceptions, and associated barriers and facilitators.

## Survey Questionnaire

1. Development: A survey questionnaire will be developed based on existing literature and expert input.
2. Content: The questionnaire will consist of sections addressing demographic information, awareness of PrEP, understanding of PrEP, sources of information, attitudes towards PrEP, and intention to use PrEP.
3. Validity and reliability: The questionnaire will undergo pilot testing to ensure its validity and reliability.
4. Administration: The survey will be administered using an online platform or in-person, depending on the feasibility and convenience for the participants.

## Limitations

Several limitations should be considered when interpreting the findings of this study. The cross-sectional design does not allow for causal inference between PrEP knowledge and willingness to use the intervention. Additionally, the use of convenience sampling may limit the generalizability of the results beyond the study population.

Data collection relied on self-reported responses, which may be subject to recall bias and social desirability bias, particularly given the sensitive nature of HIV-related behaviors. Furthermore, qualitative findings derived from focus group discussions may have been influenced by group dynamics, potentially limiting the expression of differing viewpoints.

Finally, the study was conducted in a single semi-rural setting, which may affect the transferability of findings to other contexts. Despite these limitations, the mixed-methods approach strengthened the study by providing both quantitative and qualitative insights.

1. The findings may not be generalizable to all university students in Namibia due to the specific sample selected.
2. There is a risk of social desirability bias in self-reported data.

## Reporting

The findings of this study are presented in accordance with standard scientific reporting guidelines, including structured sections covering the introduction, methodology, results, discussion, and conclusion to ensure clarity, transparency, and reproducibility.

**Table 1.** Awareness of HIV Pre-Exposure Prophylaxis (PrEP) Among University Students (n = 200)

| PrEp Awareness | Frequency (n) | Percentage (%) | 95% Confidence Interval (%) |
|---|---|---|---|
| Yes | 50 | 25.0 | 19.0 – 31.0 |
| No | 150 | 75.0 | 69.0 – 81.0 |
| Total | 200 | 100.0 | — |

Only one-quarter of the university students were aware of HIV Pre-Exposure Prophylaxis (25.0%; 95% CI: 19.0–31.0), while the majority (75.0%; 95% CI: 69.0–81.0) had never heard of PrEP. -This low level of awareness suggests that PrEP messaging has not sufficiently reached university students in Nkurenkuru Town, despite the ongoing HIV burden in the region.

The figure visually illustrates the marked disparity between students who were aware of PrEP and those who were not, reinforcing the quantitative finding of low PrEP awareness among university students.

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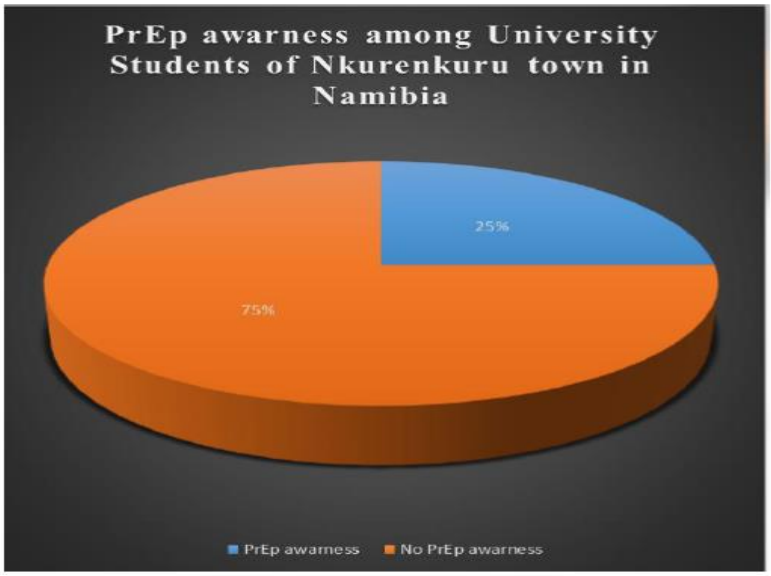


**Figure 1.** PrEP Awareness (Proportion Aware vs Not Aware)

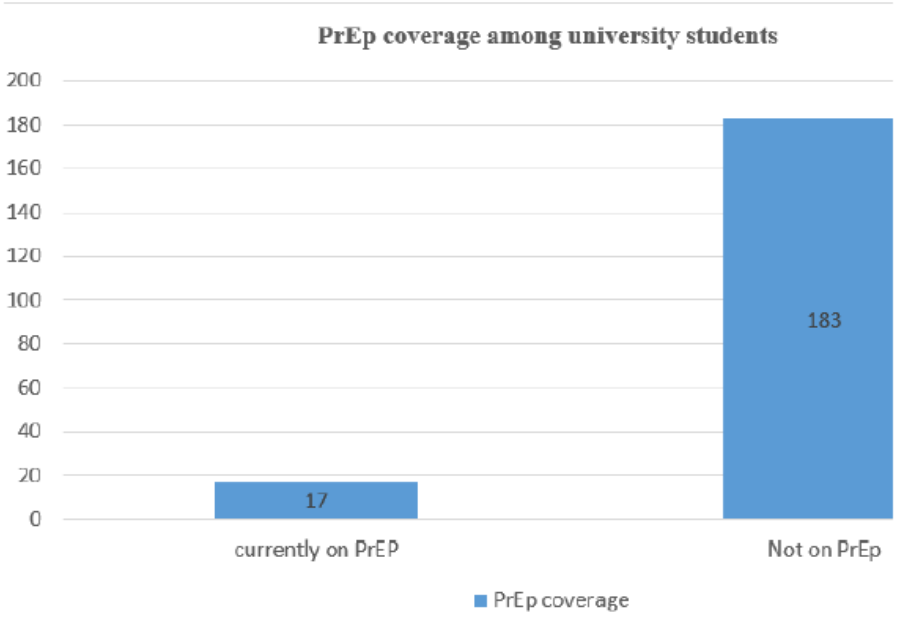


**Figure 2.** PrEP Uptake (Percentage of current users)

As per above figure2, the coverage of HIV PrEp among university student of Nkurenkuru town was low during our study period (January-December 2023) and it was noted that only 17 students from 200 were on PrEp representing 8.5% of the coverage. The figure highlights low PrEP utilization despite high willingness to use the intervention, emphasizing missed opportunities for HIV prevention among university students.

## Results

**Table 2.** Level of Knowledge of HIV Pre-Exposure Prophylaxis among University Students (n = 200)

| Level of Knowledge | Frequency (n) | Percentage (%) | 95% CI (%) |
|---|---|---|---|
| Good knowledge | 20 | 10.0 | 5.8–14.2 |
| Poor knowledge | 180 | 90.0 | 85.8–94.2 |
| Total | 200 | 100.0 | — |

**Legend:** Good knowledge was defined as correct responses to key questions on PrEP purpose, eligibility, and use. Most students (90.0%) demonstrated poor knowledge of PrEP, with only 10.0% exhibiting good knowledge of its purpose and use. This finding highlights limited understanding of PrEP among students and suggests that awareness alone may not translate into accurate knowledge without structured education.

**Table 3.** Sources of HIV Pre-Exposure Prophylaxis Information among University Students (n = 200)

| Source of Information | Frequency (n) | Percentage (%) | 95% CI (%) |
|---|---|---|---|
| Internet | 77 | 38.5 | 31.8–45.2 |
| Healthcare providers | 61 | 30.5 | 24.1–36.9 |
| Friends/family | 26 | 13.0 | 8.3–17.7 |
| Other sources | 36 | 18.0 | 12.7–23.3 |
| Total | 200 | 100.0 | — |

**Legend:** Multiple responses were allowed.

**Table 4.** Willingness to Use HIV Pre-Exposure Prophylaxis among University Students (n = 200)

| Willingness to Use PrEP | Frequency (n) | Percentage (%) | 95% CI (%) |
|---|---|---|---|
| Yes | 145 | 72.5 | 66.3–78.7 |
| No | 55 | 27.5 | 21.3–33.7 |
| Total | 200 | 100.0 | — |

**Legend:** Willingness was assessed assuming PrEP availability and recommendation by a healthcare provider. Despite low awareness and knowledge, nearly three-quarters of students (72.5%) expressed willingness to use PrEP if recommended by a healthcare provider. This finding demonstrates high acceptability of PrEP and suggests a strong potential for uptake if awareness

**Table 5.** Association between PrEP Awareness and Willingness to Use PrEP (n = 200)

| PrEP Awareness | Willing to Use PrEP | Not Willing | Total |
|---|---|---|---|
| Heard of PrEP | 45 (90.0%) | 5 (10.0%) | 50 |
| Not heard | 100 (66.7%) | 50 (33.3%) | 150 |
| Total | 145 | 55 | 200 |

**$\chi^2$ (df = 1) = 13.67, p = 0.008**

**Legend:** A significant association was observed between PrEP awareness and willingness to use PrEP. The internet (38.5%) and healthcare providers (30.5%) were the primary sources of PrEP information. This indicates that both digital platforms and healthcare settings are critical entry points for PrEP education. However, reliance on online sources may also expose students to misinformation, emphasizing the need for verified digital health communication.

**Table 6.** Association between PrEP Knowledge Level and Willingness to Use PrEP (n = 200)

| Knowledge Level | Willing to Use PrEP | Not Willing | Total |
|---|---|---|---|
| Good knowledge | 18 (90.0%) | 2 (10.0%) | 20 |
| Poor knowledge | 127 (70.6%) | 53 (29.4%) | 180 |
| Total | 145 | 55 | 200 |

**$\chi^2$ (df = 1) = 3.41, p = 0.065**

Phi coefficient (φ) = 0.13 Willingness to use PrEP was higher among students with good PrEP knowledge (90.0%) compared with those with poor knowledge (70.6%). Although this association did not reach statistical significance ($\chi^2 = 3.41$, p = 0.065), the observed effect size (φ = 0.13) suggests a positive trend, indicating that improved knowledge may enhance willingness as awareness expands.

Although willingness was higher among students with good knowledge, the association did not reach statistical significance. Students who had heard of PrEP were significantly more willing to use it compared with those who had not heard of PrEP (90.0% vs. 66.7%). The statistically significant association ($\chi^2 = 13.67$, p = 0.008) indicates that awareness is a key determinant of PrEP acceptability among university students in Nkurenkuru Town.

**Table 7.** Self-Reported Current Use of HIV Pre-Exposure Prophylaxis among University Students (n = 200)

| Current PrEP Use | Frequency (n) | Percentage (%) |
|---|---|---|
| Yes | 17 | 8.5 |
| No | 183 | 91.5 |
| Total | 200 | 100.0 |

Current use refers to self-reported PrEP use at the time of the survey. Only 8.5% of students reported current PrEP use, demonstrating a large gap between willingness to use PrEP and actual uptake. This finding underscores the influence of barriers such as limited awareness, stigma, and access constraints.

Awareness of HIV pre-exposure prophylaxis (PrEP) among university students was low, with only 25% of participants reporting prior awareness, while the majority (75%) had never heard of it (Table 1). This disparity is clearly illustrated in Figure 1, which highlights the large proportion of students lacking awareness. These findings indicate a significant gap in exposure to PrEP-related information among students in Nkurenkuru Town.

Consistent with this, knowledge of PrEP was also limited. Only 10% of students demonstrated good knowledge regarding its purpose, eligibility, and correct use, whereas 90% had poor knowledge (Table 2). This suggests that even among those who are aware of PrEP, understanding remains inadequate.

Regarding sources of information, the internet (38.5%) and healthcare providers (30.5%) were identified as the primary channels through which students obtained PrEP-related information (Table 3). Other sources, including friends and family (13.0%), played a lesser role. These findings highlight the growing importance of digital platforms alongside healthcare systems in disseminating HIV prevention information.

Despite low awareness and knowledge levels, a substantial proportion of students (72.5%) expressed willingness to use PrEP if recommended by a healthcare provider (Table 4). This indicates a high level of acceptability of PrEP among university students.

A statistically significant association was observed between PrEP awareness and willingness to use PrEP (Table 5). Students who had heard of PrEP were significantly more

willing to use it (90.0%) compared to those who had not (66.7%) ($\chi^2 = 13.67$, $p = 0.008$).

Although willingness was higher among students with good knowledge (90.0%) compared to those with poor knowledge (70.6%), this association did not reach statistical significance (Table 6) ($\chi^2 = 3.41$, $p = 0.065$; $\varphi = 0.13$), suggesting a positive but limited influence of knowledge alone.

Actual uptake of PrEP was low, with only 8.5% of students reporting current use (Table 7). This is further illustrated in Figure 2, which shows the small proportion of students currently using PrEP. These findings reveal a clear gap between willingness to use PrEP and its actual utilization.

## Qualitative Findings (Thematic Analysis)

Thematic analysis of the focus group discussions revealed four major themes related to students' knowledge, awareness, and perceptions of HIV Pre-Exposure Prophylaxis (PrEP). These qualitative findings complement the quantitative results and provide deeper insight into the observed patterns.

### Theme 1: Limited Awareness and Superficial Knowledge of PrEP

Most participants reported little or no prior knowledge of PrEP, which aligns with the quantitative finding that only 25% of students had heard of PrEP and only 10% demonstrated good knowledge.

Many students expressed uncertainty about what PrEP is, how it works, and who should use it.

> *"I have heard the name before, but I don't really know what PrEP is or how it prevents HIV."*
>
> *"Some of us confuse PrEP with ARVs for people who are already HIV positive."*

This theme supports Table 1 (PrEP awareness) and Table 2 (PrEP knowledge), confirming widespread knowledge gaps.

### Theme 2: Internet and Health Workers as Primary Sources of Information

Participants who had some awareness of PrEP reported obtaining information mainly from the internet and, to a lesser extent, from healthcare providers. This corresponds with quantitative findings showing the internet (38.5%) and healthcare providers (30.5%) as the main information sources.

> *"Most information I get about HIV prevention comes from social media or Google."*
>
> *"I only heard about PrEP when a nurse mentioned it during a clinic visit."*

However, students also noted that online information was often incomplete or confusing, contributing to misinformation.

This theme reinforces Table 3 (Sources of PrEP information).

### Theme 3: Positive Attitudes and Willingness to Use PrEP Despite Low Knowledge

Despite limited awareness, most participants expressed openness and willingness to use PrEP if it was properly explained and recommended by a healthcare professional. This finding supports the quantitative result showing that 72.5% of students were willing to use PrEP.

> *"If a doctor explains it well and says it works, I will definitely use it."*
>
> *"I think it's good protection, especially for young people like us."*

This theme explains the statistically significant association between PrEP knowledge and willingness to use PrEP observed in **Table 3 ($\chi^2 = 13.67$, $p = 0.008$)**.

### Theme 4: Misconceptions, Stigma, and Fear as Barriers to PrEP Uptake

Several misconceptions and concerns were identified as potential barriers to PrEP utilization. Some participants believed that PrEP could encourage risky sexual behavior or

feared that using PrEP would lead to being labeled as HIV positive.

> *"People might think you are sick if they see you taking pills every day."*
> *"Some think PrEP is a license to stop using condoms."*

Concerns about side effects and long-term medication use were also frequently mentioned.

These qualitative insights help explain why PrEP uptake remained low (8.5%) despite high willingness to use it.

## Discussion

This study demonstrated low levels of PrEP awareness and knowledge among university students in Nkurenkuru Town, as shown in Table 1, Figure 1, and Table 2. These findings are consistent with previous studies conducted in Namibia and other parts of sub-Saharan Africa, which report limited awareness of PrEP despite relatively good general knowledge of HIV transmission.

Despite these knowledge gaps, willingness to use PrEP was high (Table 4), indicating that acceptability is not the primary barrier to uptake. The significant association between awareness and willingness (Table 5) suggests that awareness plays a critical role in shaping PrEP acceptability. Increasing awareness could therefore serve as a key entry point for improving PrEP uptake among university students.

Although students with better knowledge were more willing to use PrEP, the lack of statistical significance (Table 6) suggests that knowledge alone may not be sufficient to drive uptake without broader awareness, supportive healthcare systems, and accessible services. This finding aligns with existing literature emphasizing the importance of combining education with structural interventions.

The internet and healthcare providers were identified as the main sources of PrEP information (Table 3), highlighting important channels for intervention. However, qualitative findings indicated that online information may be incomplete or misleading, emphasizing the need for accurate, evidence-based digital health communication and stronger involvement of healthcare providers in PrEP education.

Furthermore, the low level of actual PrEP use (Table 7 and Figure 2) despite high willingness underscores the presence of additional barriers such as stigma, misconceptions, fear of being perceived as HIV-positive, and concerns about side effects. These barriers help explain the disconnect between willingness and actual uptake observed in this study.

Overall, the findings suggest that low PrEP uptake among university students in Nkurenkuru is primarily driven by limited awareness, misinformation, and social stigma rather than lack of interest. Addressing these barriers through targeted, youth-friendly educational interventions and improved healthcare engagement is essential for increasing PrEP utilization.

These findings are consistent with recent evidence from Zambia, where low awareness but high willingness to use PrEP among university students has been reported, highlighting persistent knowledge gaps despite favorable attitudes toward PrEP use [40].

### Combined Quantitative–Qualitative Results Table (Mixed-Methods Integration)

**Table 8.** Integration of Quantitative and Qualitative Findings on PrEP Knowledge and Perceptions

| Domain | Quantitative Findings | Qualitative Themes (FGDs) |
|---|---|---|
| Awareness of PrEP | 25% of students had heard of PrEP | Most participants reported limited or no prior knowledge of PrEP |
| Knowledge level | Only 10% had good knowledge | Confusion between PrEP and HIV treatment (ART) was common |

| | | |
|---|---|---|
| Sources of information | Internet (38.5%), healthcare providers (30.5%) | Internet and clinics identified as main but sometimes unreliable sources |
| Willingness to use PrEP | 72.5% are willing to use PrEP | High willingness if PrEP is clearly explained by health professionals |
| Barriers to uptake | Low coverage (8.5%) | Stigma, fear of being labeled HIV-positive, and side-effect concerns |
| Knowledge–willingness link | Significant association ($\chi^2 = 13.67$, $p = 0.008$) | Participants emphasized that better knowledge would increase acceptance |

Integration of quantitative and qualitative findings demonstrated concordance between low levels of PrEP awareness and widespread misconceptions identified during focus group discussions. Despite limited knowledge, both data sources revealed high willingness to use PrEP if accurate information and healthcare provider support were available.

## Conclusion and Action-Focused Recommendations

The findings of this study demonstrate that both awareness and knowledge of HIV pre-exposure prophylaxis (PrEP) among university students in Nkurenkuru Town, Namibia, remain limited, with only a quarter of participants reporting prior awareness and a small proportion exhibiting adequate understanding of its use. Notwithstanding these gaps, a substantial majority of students indicated a willingness to use PrEP when recommended by a healthcare provider. Statistical analysis revealed a significant relationship between awareness and willingness to use PrEP, whereas knowledge showed a positive but statistically non-significant association with willingness.

These results suggest that improving awareness represents a crucial entry point for enhancing the acceptability of PrEP among university students. As awareness increases, strengthening accurate knowledge and addressing misconceptions may further facilitate uptake. Implementing targeted, youth-oriented educational interventions, reducing stigma associated with PrEP use, and reinforcing the role of healthcare providers in delivering clear and reliable information are essential strategies for converting willingness into actual utilization. Such approaches are particularly important in semi-rural settings, where access to accurate health information and services may be limited.

Key recommendations arising from this study include the incorporation of PrEP education into university-based health programs, alongside the strengthening of healthcare provider–driven counseling initiatives to ensure accurate and consistent messaging. In addition, the development and implementation of youth-centered awareness campaigns that address stigma and misconceptions are essential for improving acceptance of PrEP among students. Policymakers should also emphasize the delivery of reliable, evidence-based information through digital health platforms and ensure that PrEP services are readily available and accessible, particularly in semi-rural areas. Collectively, these strategies are critical for enhancing PrEP uptake and advancing national efforts aimed at reducing HIV transmission.

## Declarations

The author declares that there is no conflict of interest regarding the publication of this paper.

## Author Contributions

The author contributed to the conception and design of the study, data collection, analysis, and interpretation of results. The author also

prepared the manuscript and approved the final version for publication.

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## Ethical Approval

The study involving human participants was reviewed and approved by the relevant Institutional Ethics Committee in Namibia. Written informed consent was obtained from all participants prior to their inclusion in the study. All procedures were conducted in accordance with ethical standards and guidelines for research involving human subjects.

## Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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# Effectiveness of Community-based Distribution Methods of HIV Self-Test Kits among Female Sex Workers (FSWs) in Lagos State, Nigeria

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***Abstract*** *Community-based distribution method of HIV self–test kits is one of the distribution methods for HIV self-test uptake among Female Sex Workers (FSWs) in Nigeria. Yet it seems that understanding of its effectiveness and uptake has been on the margins among key populations (KPs) such as FSWs. To fill this gap, a cross-sectional comparative design with 375 FSWs, comprising 143 urban and 232 semi-urban residents in Lagos State, was measured and compared between the two groups to ascertain the effectiveness of the community-based distribution method of HV Self Testing (HIVST) uptake and how it could promote and sustain a long-term health care system in the context of HIVST uptake. Data for this study were collected using a structured questionnaire and analyzed using SPSS. The key finding showed that overall, 86% of both urban and semi-urban participants affirmed the effectiveness of community-based distribution methods of HIVST. The main reasons included non-stigmatization, lack of discrimination, regard for FSWs, confidentiality, and cost-effective uptake. Statistical analysis revealed significant differences between community-based and other distribution models ($p < 0.05$). However, minimal awareness of community-based distribution was identified. In the alternative, the study shows that intervention to redress this challenge can promote and sustain the effectiveness of community-based HIVST distribution, contribute valuable information to the field of HIV prevention and care, offer insights that can inform targeted approaches to enhance HIV testing uptake, meet the health needs of FSWs living with HIV, thereby mitigating the spread of the disease and contributing to improved health conditions.*

***Keywords*** *Community-based Distribution, Female Sex Workers (FSWs), HIV Control, HIV Self-Testing, Nigeria, Sustainable Health.*

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## Introduction

The complex effects of HIV in the developing regions of the world such as Africa have made the study of HIV self-testing increasingly important. Globally, in 2024, about three-quarters of the 40.8 million [37.0 million–45.6 million] people living with HIV were receiving antiretroviral therapy (77% [62–90%]) and (73% [66–82%]) had suppressed viral loads—a huge public health achievement [1].

In sub-Saharan Africa (SSA), which is home to more than 60% of all people living with HIV, the provision of antiretroviral therapy, among other advances, has led to a rebound in life expectancy from 56.5 years in 2010 to 62.3 years in 2024 [1].

Despite recent progress, the prevalence of HIV in sub-Saharan Africa (SSA) remains high and an issue of urgent policy and research concern. Recent global data show that the HIV response may be in crisis, as a decline in funding poses a new challenge, yet there is power to transform the vulnerable population [1-4].

Importantly, in Africa, Female Sex Workers (FSWs) are among the most vulnerable groups, whose activities contribute to the spread of the epidemic [5]. A recent study shows that FSWs have a higher prevalence rate and exposure to risk at least 12 times higher than women who are not sex workers [6].

For example, across Central and West Africa, in 2019, among 4.9 million persons living with HIV, about 240,000 were newly infected, while 140,000 died of conditions linked to AIDS [7, 8]. Data from the Joint United Nations Programme on HIV/AIDS (UNAIDS) show that of all those living with HIV in Central and West Africa at the end of 2019, only 68% knew their serological status [8]. Nigeria is included in the prevalence of the epidemic and also confronted with the challenges of awareness and knowledge of the status of the epidemic among infected persons through HIVST.

In Nigeria, in 2025, UNAIDS and the National Agency for the Control of AIDS (NACA) estimate that there are 1.9 million people living with HIV in Nigeria [9]. Like most countries in West Africa, the concentration of HIV epidemic among key populations such as female sex workers (FSWs) have been high. Recent World Health Organization data show that among vulnerable groups to new infection are female sex workers (FSWs) [10, 11] as the group has the potential of transmitting the disease to various sexual partners. However, with effective HIVST uptake, over 85% of the vulnerable group will not transmit or spread HIV [ 8].

A 2025 survey in Lagos found an increasing rate of new HIV infection, including FSWs [12]. FSWs face a significant and persistent risk of contracting HIV. FSWs account for about 20% of new HIV infections in Nigeria. Undiagnosed HIV infection remains substantial in key population subgroups, including FSWs,9, driving ongoing transmission in sub-Saharan Africa.

Self-testing is a new way for people to learn their HIV status and, if confirmed HIV-positive, obtain treatment and prevention services [13, 14]. HIV self-testing is becoming much more widely available. Various programmes are emerging in a number of countries. As of July 2018, more than 40 countries report having policies to allow self-testing, many of which are now implementing self-testing programmes to some degree [15]. Recent 2025 data on HIVST suggest the increasing relevance of self-testing [1, 6, 7 ].

There are various distribution models for HIV self -testing such as vending, pharmacies, distribution by peers, community-based distribution, pick-up from a store, mail delivery, online ordering, and facility-based distribution. Self-testing can provide more flexibility for clients and health care service providers [9].

Distribution during campaigns, at events, mobile outreach, or home-based (door-to-door)

distribution. Integration with existing community-based testing programmes can improve efficiency and optimize resources. Thus, the effectiveness of community-based HIV Self-testing among female sex workers (FSWs) has attracted recent scholarly attention following the persistent rise of HIV infection, particularly the rise of new infections [16-18]. Community-led models are likely to be effective. For example, a recent study found that community-based HIVST is cheap and affordable [17]. Similarly, WHO elaborates that communities are important to make HIV self-testing safe, acceptable, and effective [9]. Community organizations can significantly shape norms to support self-testing and its appropriate use. In a cluster randomized trial in Malawi, a study demonstrated that community-led HIVST was effective, safe, and affordable. [19].

However, despite the growing concern about the effectiveness of HIVST uptake, it appears that a comparative study of the effectiveness of community-based distribution methods of HIV Self-testing among FSWs has been in the margins of research in most developing countries. For example, there is a dearth of research on community-based HIVST among key populations in most urban and semi-urban localities in the low-income countries of Africa. Particularly, there is limited evidence of perceptions and reasons for the effectiveness of community-based distribution methods of HIV Self –testing among FSWs in Nigeria in particular.

The study of Nigeria is important not only because it is the most populous country in Africa but it is essential to identify some of the key enablers that are responsible for the effectiveness of community-based HIVST distribution, and in particular, to promote the treatment and prevention of the spread of HIV among FSWs against stigmatization [20-22]. Such testing and knowledge of status, according to [6] are starting points for HIV treatment and prevention interventions.

It is against the background of scant research in this subfield that this study aims to fill this research gap by exploring the effectiveness of community -based distribution methods of HIVST kits in Lagos State, Nigeria. The study compared three HIVST kits distribution methods, namely, community-based, online, and pharmacy-based, drawing on responses from FSWs to understand their lived experience on issues of confidentiality, stigmatization, affordability, discrimination, and inclusiveness.

The contribution of this study is threefold. First, the study offers a deepened comparative analyses that draw on lived experience of FSWs in urban and semi-urban settings in Lagos State to understand their perceptions and preferences among three types of HIVST distribution methods, Secondly, such knowledge helps health care practitioners and policy makers to promote the mitigation of the spread of HIV and thirdly creates new awareness on the need for community based distribution method of HIVST and its divergent importance in promoting good health and wellbeing of key populations in line with UNAIDS agenda and the SDG goals.

## Aim of the Study

To ascertain the effectiveness of community-based distribution methods of HIV self-test kits among Female Sex Workers in Lagos state, Nigeria.

## Objectives

1. To ascertain the extent to which the community-based distribution method of HIVST kits is more confidential than online and pharmacy distribution methods among FSWs.
2. To determine the extent to which community-based distribution methods of HIVST kits are less stigmatizing than online and pharmacy-based distribution methods among FSWs.

3. To examine the extent of community-based distribution method of HIVST kits, mitigate discrimination among FSWs.

### Significance of the Study

This study will generate evidence on the most effective community-based approaches for distributing HIV self-test kits to Female Sex Workers (FSWs), a key population at increased risk of HIV infection in Lagos State and across Nigeria. The findings help improve early HIV diagnosis among FSWs by identifying the HIVST distribution methods that are more acceptable, confidential, convenient, and accessible to this population.

## Materials and Methods

### Study Design

This study adopted a cross-sectional qualitative design conducted in Lagos State, Nigeria and examined 13 FSWs communities. The study explored the effectiveness of community-based distribution approaches for HIV self-testing (HIVST) kits in enhancing uptake among this population.

The study used simple random sampling technique to collect field data among participants. The research relies on extensive qualitative data collected from FSWs in the study sites. Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) were conducted. Data was presented in tables and analyzed statistically using simple regression.

### Research Question

1. To what extent is the community-based distribution method of HIVST kit more confidential than online and pharmacy-based distribution methods of HIVST kits among FSWs?
2. To what extent is the community-based distribution method of HIVST kits less stigmatizing than online and pharmacy-based uptakes among FSWs?
3. To what extent does the community-based distribution method of HIVST, mitigate discrimination among FSWs

### Research Hypotheses

- **$H_1$** Community-based distribution method of HIVST kits uptake is more confidential than online and pharmacy-based distribution methods of HIVST kits among FSWs.
- **$H_2$** Community-based distribution method of HIVST kits is less stigmatizing than Online and Pharmacy uptake among FSWs.
- **$H_3$** Community-based distribution method of HIVST mitigates discrimination among FSWs.

### Study Area

This study was conducted in Lagos State, Nigeria. The specific sites of this study included randomly selected urban and semi-urban areas in Lagos State. Studies have shown that FSWs predominantly reside in urban centers (cities) and semi-urban areas adjoining urban localities [23].

### Population and Sample Size

The population for the study consists of 375 FSWs aged 18-45 years who have accessed services from OSS treatment facilities. FSWs who have self-tested within the last three years were chosen using a multistage sampling technique. In order to ensure homogeneity within each cluster, the FSWs were first grouped using cluster sampling. Purposive sampling was used in the second phase to choose FSWs who fall into the designated demographic range.

Furthermore, proportionate sampling was used to guarantee representation from the studied sites.

The Taro Yamane formula was adopted to determine the sample size below;

$$n = \frac{N}{1 + N(e)2}$$

Where: N is the population (44112908)

1 is constant
e is the sampling error
n is the sample size
Adopting substitution method

$$n = \frac{44112908}{1 + 44112908(0.05)^2}$$

$$= \frac{44112908}{1 + 44112908 \times 0.0025}$$

$$= \frac{44112908}{1 + 110282.27}$$

$$= \frac{44112908}{110283.27} = 399.99$$

Sample size (n) = 400

## Data Collection Instruments

Structured questionnaires were used in collecting data from the respondents. The instrument was designed in English language, and local dialect as applicable, wherein the questions were cross-checked to verify the context. Trained research assistants administered the questionnaires and also conducted the FGDs. The tool was pretested in Agege CF, and adjustments and necessary corrections were made before going for the field survey.

### Approach

From October 2025 to December 2025, community- based distributors (CBDs) in Lagos State in FSWs communities administered questionnaires, organized (5) focus group discussions (FGDs) with FSWs on their perceptions on the effectiveness of community-based distribution methods of HIVST, amongst FSWs in the brothels, local inn and pub houses. Targeted communities under investigation were selected using simple random sampling. The specific urban and semi-urban sites were randomly selected for the study using a random number generator. The study population comprised of FSWs across the selected urban and semi-urban communities. The sampling was used to select 13 FSWs communities from five (5) purposively selected wards in Lagos State and 13 community-based distributors. The study involved a final total sampling of 375 FSWs, who are knowledgeable of HIVST distribution in urban and semi-urban Lagos State between October 2025 to December 2025.

CBDs were identified, which included a network of FSWs recruited and trained from each of their communities to explore the effectiveness of community-based distribution methods of HIV Self-test kits at the community. The selection of a network of FSWs as CBDs was informed by the fact that they have easy access to the FSWs, they are knowledgeable of their various locations, including timing, and there is no discrimination or stigma. Most of the network members have previous experience of working with HIV programmes, community work, literacy levels and good standing in the community. Hence, CBDs were a heterogeneous group with different backgrounds and levels of experience. We undertook a 2-day training on how to administer the questionnaire, providing information to promote and support linkage to elicit perceptions on comparative responses on the effectiveness of community-based distribution, online, and pharmacy uptakes.

Each locality (urban or semi-urban) had the smallest subunit of a ward that varies in size but typically has about 100 households, had one or two CBDs depending on size. Within the period of October 2025 to December 2025, CBDs conducted visits to FSWs in brothels, interacting with them on the effectiveness of community, online, and pharmacy-based distribution methods of HIVST kits. Questionnaire and focus groups were conducted with only FSWs who were willing and gave their consent. Research assistants and CBDs recorded the responses. The primary outcomes were to determine FSWs' perception on the effectiveness of community, online and pharmacy -based distribution methods of HIVST kits. FSWs' perception was accessed across nine items using a 2-point Likert-scale instrument, "Agreed" and "Disagreed", with

'Agreed' assigned a score of "1" and 'Disagreed' "0", while effectiveness of community based HIVST uptake was assessed using a 10-point Likert Scale where "1" was extremely effective and "10" was extremely ineffective. The effectiveness or otherwise were analyzed as primary outcome.

### Inclusion and Exclusion Criteria

All FSWs aged 18 to 45 years and who have participated in or knowledgeable of community-based distribution methods of HIVST for at least six months, were selected from the client registers of OSS facilities for this investigation and included, while those that did not meet the inclusion criteria were excluded.

### Data Analysis

Data on perceptions of FSWs on the effectiveness of community-based distribution methods of HIVST kits were analyzed using SPSS statistical package. The mean score rating (between ratings 1-10) was used in determining the cut-off for categorizing effectiveness scores. FSWs with effectiveness scores greater or equal to the cut-off were classified as "effective," or otherwise, "ineffective." Adjusting for all variables, t-test was used to test the hypotheses among urban and semi-urban residents while logistic regression analysis was used to determine differences in response to effectiveness or otherwise by respondents at a significant p-value $\leq 0.05$. Reasons for effectiveness and ineffectiveness ratings were summarized descriptively.

### Ethical Consideration

This study was approved by Nigeria's National Health Research Ethics Committee (NHREC)with approval number; (NHREC Approval Number NHREC/01/01/2007-08/08/2025). The conduct of this study followed ethical guidance. FSWs who consented to participate in the study were assured of their confidentiality, informed of the study objectives, and the duration of the processes of field data collection.

Eligible FSWs based on our inclusion criteria were interviewed by the research assistants using a structured questionnaire. The questionnaire assessed FSWs' perception on the effectiveness of the community-based distribution method of HIVST kits. Five (5) focused group discussions (FGDs)were organized and discussions were tailored towards extracting information in line with the research objectives. English language, Pidgin-English and local dialects were used in some instances in the interactions based on the respondent's preferences. All responses in Pidgin and local dialects were transcribed verbatim in English. In securing and analyzing field data for the study, a high level of confidentiality was maintained. Only select research members directly involved in the study had access to the identified data, its analyses or processes of collation of the result.

## Results

### Socio-demographic Characteristics

Respondents' socio-demographic-characteristics included age, gender, educational qualification, occupation, residence, the duration they have experienced or undertaken HIVST. Table 1 shows that 90% of the respondents were aged 15–45 years, marital status, married 16%, Divorced/Separated 24%, Not married 70%, different levels of education (21% none, 41% primary, 23% secondary, 15% tertiary) and occupations (55% students (literate), 26% artisans, 19% traders). Urban residents (28%), semi-urban residents (72%), and six to eight months experience with HIVST (98%).

**Table 1.** Socio-demographic Characteristics of FSWs Experienced on HIVST

| Items | Variable | Percentage (%) |
|---|---|---|
| Residence | Urban | 28 |
| | Semi-urban | 72 |
| Age | 15-45years | 90 |
| Marital Status | Married | 16 |
| | Divorced/Separated | 24 |
| | Not married | 70 |
| Education | None | 21 |
| | Primary | 41 |
| | Secondary | 23 |
| | Tertiary | 15 |
| Occupation | Students | 55 |
| | Artisans | 26 |
| | Traders | 19 |
| Experience with HIVST uptake | Six to Eight months | 98 |

## Result Presentation and Analyses

- **Research Question One:** To what extent is the community-based distribution method of HIVST kits more confidential than online and pharmacy distribution methods among FSWs.
- **Hypothesis One ($H_1$):** There is no significant difference in confidentiality between community-based HIVST uptake with online and pharmacy distribution uptakes among FSWs.

**Table 2.** T-test Analyses of Confidentiality of Community-based Distribution, Method of HIVST Uptake among Urban and Semi-urban FSWs Resident in Lagos State

| Variables | Mean | SD | N | t-test | P-Value | Alpha | df | Decision |
|---|---|---|---|---|---|---|---|---|
| Urban | 21.22 | 2.91 | 143 | 2.81 | 0.000 | 0.05 | 248 | Reject Ho1 |
| Semi-urban | 25.42 | 4.56 | 232 | | | | | |

The result of the data analysis as shown in table 4.1 indicates that the urban residents had a mean value of 21.52 (SD 2.91), while semi-urban residents had a mean score of 25.42 (SD = 4.56). The independent t-test score obtained from the analysis further showed that a value of 2.81 was gotten which indicates a strong evidence of the influence of community based distribution method of HIVST uptake on confidentiality among FSWs unlike online and pharmacy uptakes Testing of the associated hypothesis yielded a p-value of 0.000, which was less than the significant alpha of 0.05. This result showed that there is significant evidence of the influence of community-based distribution method of HIVST uptake on confidentiality among FSWs. The null hypothesis was therefore rejected.

- **Research Question Two:** To what extent is community-based distribution of HIVST, less prone to stigmatization than Online and Pharmacy uptakes among FSWs?
- **Hypothesis Two ($H_2$):** There is no significant difference on stigmatization in community, Online and Pharmacy HIVST uptake among FSWs

**Table 3.** T-test Analyses of Difference in Stigmatization in Community, Online and Pharmacy based HIVST Uptake among Urban and Semi-urban FSWs resident in Lagos State

| Variables | Mean | SD | N | Df | t-test | P-Value | Alpha | Decision |
|---|---|---|---|---|---|---|---|---|
| Urban | 26.56 | 2.04 | 143 | 248 | 2.721 | 0.0004 | 0.05 | Reject $H_O2$ |
| Semi-urban | 21.42 | 4.56 | 232 | | | | | |

The result of the data analysis as shown in table 4.2 indicates that urban residents had a mean value of 26.56 (2.04) while semi-urban had mean score of 21.42 (SD = 4.56). This means that there is less stigmatization in community-based distribution method of HIVST uptake among FSWs unlike online and pharmacy uptakes. The independent t-test score obtained from the analysis further showed that a value of 2.721 was gotten which indicates a significant difference on non-stigmatization in community-based HIVST uptake. Testing of the associated hypothesis yielded a p-value of 0.004, which was less than the chosen alpha level of 0.05. This result showed that there is a significant difference on stigmatization in community based HIVST uptake. The hypothesis was therefore accepted.

- **Research Question Three:** To what extent is community-based distribution method of HIVST kits more affordable than online and pharmacy HIVST kit distribution uptake among FSWs?
- **Hypothesis Three ($H_3$):** There is no significant difference in affordability of community-based distribution, HIVST, online and pharmacy HIVST distribution uptake among FSWs

**Table 4.** T-test 3 Community, Online and Pharmacy based HIVST Distribution Uptake among Urban and Semi-urban FSWs Resident in Lagos State

| Variables | Mean | SD | N | Df | t-test | P-Value | Alpha | Decision |
|---|---|---|---|---|---|---|---|---|
| Urban | 26.34 | 2.33 | 143 | 248 | 2.507 | 0.041 | 0.05 | Reject $H_O3$ |
| Rural | 24.42 | 4.56 | 232 | | | | | |

The result of the data analysis, as shown in Table 4.3, indicates that urban residents had a mean value of 26.34 (SD = 2.33), while semiurban residents had a mean score of 24.42 (SD = 4.56). The independent t-test score obtained from the analysis further showed that a value of 2.507 was gotten, which indicates a significant difference on the influence of affordability in community-based distribution method of HIVST uptake among FSWs unlike online and pharmacy uptakes. Testing of the associated hypothesis yielded a p-value of 0.041, which was less than the chosen alpha level of 0.05. This result showed that there is a significant difference in the affordability of the community-based distribution method of HIVST kits compared to online and pharmacy uptakes.

## Discussion

This comparative study aimed to examine the effectiveness of the community-based distribution method of HIVST kits among FSWs in Lagos State. The study compared the community-based distribution method of HIVST kits with the online and pharmacy-based distribution method through the responses of urban and semi-urban FSWs.

The study examined perceptions of FSWs on the effectiveness of community-based distribution methods of HIV Self –test kits among Female Sex Workers (FSWs) in Lagos State, Nigeria. The study adopted a

comparative survey design method with eight item statements to ascertain perceptions and reasons for such effectiveness. It examined issues of confidentiality, stigmatization, and affordability in HIVST uptake among FSWs.

The main finding showed that both urban and semi-urban participants preferred the community-based distribution method of HIVST kits to online and pharmacy-based distribution. Beyond proximity and affordability, community-based distribution method of HIVST kits is conducted by FSWs drawn from peer groups, it guarantees confidentiality and has no form of stigmatization or discrimination, unlike other distribution methods.

The findings provided insights into the effectiveness and acceptability of community-based distribution method of HIVST through the responses of both urban and semi-urban FSWs. Recent UNAIDS report suggests the need to promote HIVST in order to mitigate the spread of the disease and to meet the 2030 target [24]. A related finding revealed that the community-based distribution method is more user-friendly. For example, in their study, [25] found that community-based model has positive outcomes through well-trained staff, patient-centered care, and technology integration, while facing challenges such as system inefficiencies and access due to lack of funding.

The online-based model helps to overcome long waiting time as it is swift and less time-consuming. However, from the respondents in our field data, it may not guarantee same confidentiality and affordability as the community-based method since FSWs must have access to the internet or at least use an Android phone. The economically disadvantaged FSWs among them complained of the challenge of affordability; others claimed they do not have money to buy data for network access. Others said they cannot use cybercafes or public places to uphold their confidentiality.

The pharmacy method and similar facility-based models are useful in building-trust, offering of comprehensive care services, and has ART availability, however most of the FSWs elaborated a number of challenges both at the individual and broader societal levels. AS the FSWS stated that as individuals they are stigmatized and discriminated while using such facilities.

A number of previous studies have made similar findings. For example, in their study on differentiated HIV service deliver among FSWs, [26] found that community-based service delivery is most effective.

The findings reinforce the need for more awareness campaigns and intervention, community engagement, inclusive local care delivery service, improved technology know-how, and new approaches to address institutional challenges such as discrimination and stigmatization for effective and inclusive HIVST uptake for FSWs. Although the use of community-based distribution methods proves effective, relying solely on community-based methods could slow down effective transformation in line with 2030 agenda.

## Scope

This study focused on assessing the effectiveness of community-based distribution methods of HIV self-test (HIVST) kits among Female Sex Workers (FSWs) in Lagos State. The study was limited to selected FSWs operating within major hotspots, brothels, streets, bars, clubs, and other community settings in the state. Geographically, the study covered selected Local Government Areas (LGAs) in Lagos State where there is a high concentration of FSWs and where HIV self-testing interventions are being implemented by government and partner organizations. These LGAs may include urban and semi-urban areas with active HIV prevention programmes.

However, the study was restricted to HIV self-test kit distribution and did not include other HIV prevention interventions such as

condom distribution, pre-exposure prophylaxis, sexually transmitted infection treatment, or antiretroviral therapy services except where these were discussed in relation to linkage after HIVST. The study did not include male sex workers or other key populations such as men who have sex with men or people who inject drugs. Therefore, the findings are specific to FSWs in Lagos State and may not be generalized to other populations or settings

## Implications for Research and Practice

The complex effects of HIV in developing countries such as Africa have made the study of HIV self-testing increasingly important. There is scant evidence of comparative studies on the effectiveness of community-based distribution of HIVST kits among FSWs in Lagos State, South West Nigeria, and the country at large. This has made comparative research on the effectiveness of community-based HIV Self-testing among FSWs important. Understanding the effectiveness of the community-based distribution method of HIVST kits among FSWs is essential for HIV prevention programming and services. The study has the potential to improve HIV testing uptake, increase early identification of HIV infection, and strengthen linkage to care among FSWs, thereby contributing to national HIV prevention goals and the achievement of the 95-95-95 targets promoted by the Joint United Nations Programme on HIV/AIDS.

## Contribution to Knowledge

This study contributes to existing knowledge by providing empirical evidence on the effectiveness of different community-based distribution methods of HIV self-test (HIVST) kits among Female Sex Workers (FSWs) in Lagos State. Although previous studies have shown that HIV self-testing can improve access to HIV testing among key populations, there is limited evidence on which specific community-based distribution methods are most effective for reaching FSWs in the Nigerian context. By focusing on FSWs, the study addresses an under-researched population in HIV self-testing literature within Nigeria. Much of the existing literature has focused on the general population or other key populations, leaving limited evidence specific to FSWs.

The findings provide evidence that may be used to refine and strengthen HIV self-testing policies and programmes implemented by the National AIDS, Viral Hepatitis and STIs Control Programme and, the Lagos State AIDS Control Agency, and partner organizations The study highlights the central role of peer educators and peer networks in improving HIVST uptake, thereby contributing to the understanding of peer-led interventions among key populations. It expands knowledge on the barriers and facilitators that influence HIVST use among FSWs, including stigma, confidentiality, convenience, trust, fear of positive results, and access to follow-up services. By focusing on FSWs, the study addresses an under-researched population in HIV self-testing literature within Nigeria. Much of the existing literature has focused on the general population or other key populations, leaving limited evidence specific to FSWs. The findings provide evidence that may be used to refine and strengthen HIV self-testing policies and programmes implemented by the National AIDS and STDs Control Programme, the Lagos State AIDS Control Agency, and partner organizations. The study also serves as a foundation for future research by identifying areas that require further investigation, such as the cost-effectiveness, sustainability, and long-term outcomes of community-based HIVST distribution methods.

## Recommendations for Future Research

There is a need to expand research in Nigeria that explicitly investigates HIVST distribution models among FSWs. The limited number of existing studies in this area leaves a critical gap, as this population group is considered hard to reach. Future research should incorporate cost-

effectiveness analyses to evaluate the economic viability of different HIVST distribution methods. Understanding the cost per individual reached, per HIV-positive case identified, and per person linked to care will provide critical evidence for policymakers and programme implementers, particularly within the context of resource constraints. Additionally, to broaden methodological approaches, a future study should adopt more rigorous research designs, such as randomized controlled trials or quasi-experimental approaches, to enable stronger causal inference when comparing the effectiveness of different HIVST distribution models. While this study provides important insights, more robust comparative evidence is needed to determine the most effective strategies across diverse contexts of public health services.

## Conclusion

Community-based HIVST uptake was effective, affordable, and safe; issues of stigmatization, discrimination, neglect, and disregard for FSWs were minimal, as some of the major factors that were responsible for the effectiveness of community-based HIVST kit distribution. This has not only promoted the uptake of community-based HIVST, but it has also helped to control the spread of the disease, promote increasing response to community-based distribution, strengthen the knowledge of health status of FSWS, and importantly mitigate the spread of new HIV infections.

This has serious urgent policy implications. To this end, policymakers, community leaders, and relevant stakeholders should step up various interventions at promoting community based HIVST kit distribution for increase HIVST uptake to address the critical health challenges of key population, through effective public awareness campaigns, workshops, and enlightenment programmes at the community level, to check ill treatments to FSWs and in particular, meet the health needs of FSW. The essence is to promote and sustain the effectiveness of community-based distribution methods, eliminate the spread of disease, contribute to better health outcomes, and institutionalize a broader anti-discrimination community.

## Conflict of Interest

The author has declared none.


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There is no funding to report, the author funded this study.


## Data Availability

Yes, and were included in the result section.

## Ethical Approval

This study was approved by Nigeria's National Health Research Ethics Committee (NHREC).

## Author Contributions

The first author conceptualized and coordinated the research; the second author provided technical guidance and approval, reviewed, and supported data synthesis. The third and fourth authors supported the review of draft narratives, participated in conflict resolution. all authors contributed to the final manuscript.


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# Factors Influencing the Management of Type 2 Diabetes among Patients at the Nylon District Hospital in Douala, Cameroon

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***Abstract*** *Type 2 diabetes mellitus (T2DM) is one of the leading chronic non-communicable diseases worldwide and constitutes a major public health problem in low- and middle-income countries. Poor therapeutic adherence, inadequate nutritional practices, limited communication, and socioeconomic constraints significantly affect the management of this condition. This study aimed to identify the factors influencing the management of type 2 diabetes among patients attending the Nylon District Hospital in Douala, Cameroon. A descriptive cross-sectional study was conducted from November 2024 to July 2025 among 200 patients diagnosed with T2DM. Data were collected using a structured questionnaire after informed consent and analyzed using Microsoft Excel, Epi Info, and RStudio software. Results revealed that males represented 62% of participants while patients aged above 60 years constituted 63% of respondents. About 34% of respondents regularly consumed alcohol, while 19% had never participated in any diabetes education program. Furthermore, 63% perceived healthcare personnel as inaccessible or aggressive, and 81% had previously interrupted treatment. Financial constraints, inadequate communication on diabetes, and poor adherence to dietary recommendations were among the major barriers identified. The findings suggest that improving therapeutic education, strengthening communication strategies, and facilitating access to medication could significantly improve the outcomes of diabetes management.*

***Keywords*** *Communication, Cameroon, Nutrition, Type 2 Diabetes, Therapeutic Adherence.*

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## Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from insulin resistance and impaired insulin secretion by pancreatic β-cells [1, 2]. It is currently recognized as one of the most important non-communicable diseases worldwide because of its rapidly increasing prevalence, associated complications, and socioeconomic burden. According to the International Diabetes Federation (IDF), diabetes affects hundreds of millions of people globally, and approximately 90–95% of all diabetes cases are attributed to T2DM [3]. The World Health Organization (WHO) further reports that diabetes is among the leading causes of morbidity and mortality worldwide, contributing significantly to cardiovascular diseases, kidney failure, blindness, lower-limb amputations, and premature deaths [1]. The growing burden of diabetes is strongly associated with urbanization, population aging, sedentary lifestyles, obesity, and unhealthy dietary practices [4, 5].

Over the past decades, the prevalence of diabetes has increased considerably in low- and middle-income countries, particularly in sub-Saharan Africa where healthcare systems often face significant resource limitations [6, 7]. Africa is currently experiencing a rapid epidemiological transition characterized by increasing rates of obesity, physical inactivity, and unhealthy nutritional habits, all of which contribute to the rising incidence of T2DM [9]. The WHO Africa Regional Office estimates that the number of adults living with diabetes in Africa will continue to rise dramatically in the coming years if adequate preventive and management strategies are not implemented [11]. In addition, many cases remain undiagnosed, thereby exposing patients to severe complications before appropriate treatment is initiated [15].

Cameroon is equally affected by this growing epidemic. Diabetes has become a major public health challenge because of its impact on morbidity, mortality, and healthcare expenditure [6]. Previous studies conducted in Cameroon have reported increasing prevalence rates in both urban and rural settings, although urban populations remain disproportionately affected due to changes in lifestyle, dietary habits, reduced physical activity, and increased stress levels associated with modernization [13, 14]. The burden of diabetes in Cameroon is further aggravated by limited access to healthcare services, poor health-seeking behaviors, inadequate patient education, and the high cost of long-term treatment [12]. Consequently, many diabetic patients experience poor glycemic control and develop chronic complications such as cardiovascular diseases, neuropathy, nephropathy, retinopathy, and diabetic foot ulcers [10, 12].

Effective management of T2DM requires a comprehensive and multidisciplinary approach involving adherence to dietary recommendations, regular physical activity, blood glucose monitoring, medication compliance, and continuous therapeutic education [8, 16]. Diabetes self-management education and support programs play a critical role in empowering patients to make informed decisions regarding their health and improve therapeutic adherence [17, 18]. However, despite the availability of treatment guidelines and educational interventions, many diabetic patients continue to encounter numerous barriers to effective disease management. These barriers include financial difficulties, poor communication between healthcare providers and patients, inadequate family or social support, low levels of knowledge concerning the disease, and unhealthy lifestyle behaviors such as excessive alcohol consumption and poor dietary practices [16–18].

In many healthcare settings within sub-Saharan Africa, diabetes management is also hindered by irregular availability of

medications, insufficient healthcare infrastructure, and limited access to trained healthcare professionals [7, 10]. Poor adherence to treatment and follow-up appointments remains a major concern because it contributes significantly to disease progression and the occurrence of complications. Furthermore, misconceptions regarding diabetes and reliance on alternative treatment methods may negatively influence adherence to prescribed therapies and medical recommendations [4, 5].

Given the increasing prevalence of T2DM and the numerous challenges encountered by diabetic patients in Cameroon, there is a need to better understand the determinants influencing disease management in healthcare facilities. Identifying these factors is essential for developing effective interventions aimed at improving therapeutic adherence, reducing complications, and enhancing the quality of life of diabetic patients. It is within this context that the present study was conducted at the Nylon District Hospital in Douala to investigate the factors influencing the management of type 2 diabetes among patients attending this health facility.

The general objective of this study was to identify the determinants influencing the management of type 2 diabetes among diabetic patients. Specifically, the study sought to identify nutritional determinants influencing T2DM management, determine communication-related determinants influencing T2DM management, identify socioeconomic determinants influencing T2DM management, and determine medication-related determinants influencing T2DM management.

## Methodology

### Study Design

A descriptive cross-sectional study with a quantitative approach was conducted among patients diagnosed with type 2 diabetes mellitus (T2DM).

### Study Site

The study was carried out at the Nylon District Hospital located in Douala, the economic capital of Cameroon. Douala is a highly urbanized city characterized by rapid population growth, sedentary lifestyles, and increasing prevalence of non-communicable diseases, including diabetes. The Nylon District Hospital is one of the major public healthcare facilities in the city and provides outpatient and inpatient healthcare services to a large and diverse population. The hospital includes consultation units, laboratory services, and chronic disease follow-up services where diabetic patients receive regular medical care and therapeutic monitoring.

### Study Period

The study was conducted over a period of nine months, from November 2024 to July 2025. This duration allowed adequate time for participant recruitment, data collection, verification of questionnaires, data entry, and statistical analysis.

### Study Population

The study population consisted of patients diagnosed with type 2 diabetes mellitus attending the Nylon District Hospital during the study period. Participants were recruited from the diabetic consultation and follow-up units of the hospital. Both male and female patients were included in the study regardless of their socioeconomic background or duration of illness.

### Inclusion Criteria

Participants were included in the study if they met the following criteria:

1. Patients who were diagnosed with type 2 diabetes mellitus by a healthcare professional.
2. Patients who attended the Nylon District Hospital during the study period.

3. Patients who voluntarily agreed to participate in the study and signed an informed consent form.

## Exclusion Criteria

The study excluded:

1. Patients who were diagnosed with type 2 diabetes mellitus but were severely ill and unable to respond to the questionnaire.
2. Patients who refused to provide informed consent.

## Sample Size and Sampling Technique

A total of 200 diabetic patients participated in the study. Participants were recruited using a convenience sampling technique based on their availability and willingness to participate during consultation visits at the hospital. This sampling method was considered suitable because it facilitated access to diabetic patients attending routine follow-up services.

## Data Collection Procedure

Data were collected using a structured questionnaire developed according to the objectives of the study and relevant literature on diabetes management. The questionnaire was divided into several sections covering sociodemographic characteristics, nutritional practices, alcohol consumption, communication and educational factors, socioeconomic determinants, medication adherence, and treatment interruption.

Before data collection, participants were informed about the purpose and significance of the study. After obtaining informed consent, the questionnaires were administered directly to respondents in either French or English depending on the participants' preferences and level of understanding. Assistance was provided to participants who experienced difficulties in reading or interpreting certain questions.

The questionnaire was pretested among a small group of diabetic patients outside the study population to assess clarity, relevance, and comprehension of the questions. Necessary corrections and adjustments were made before the final administration of the tool.

## Study Variables

The dependent variable of the study was the management of type 2 diabetes mellitus. Independent variables included sociodemographic characteristics, dietary habits, alcohol consumption, participation in educational programs, communication channels, perception of healthcare personnel, cost of treatment, source of financing, duration of illness, and therapeutic adherence.

## Data Management and Statistical Analysis

Completed questionnaires were checked daily for completeness and consistency before data entry. Data were coded and entered into Microsoft Excel before being exported to Epi Info and RStudio software for statistical analysis.

Descriptive statistical analyses were performed. Frequencies and percentages were calculated for categorical variables and presented using tables and figures. The findings were interpreted according to the objectives of the study and compared with existing literature on diabetes management.

## Ethical Considerations

Ethical principles were strictly respected throughout the study. Administrative authorization to conduct the study was obtained from the relevant hospital authorities before data collection commenced. Participation in the study was entirely voluntary, and informed consent was obtained from all participants prior to enrollment.

Confidentiality and anonymity were ensured by not recording participants' names or personal identifiers on the questionnaires. Participants were informed that the information collected would be used strictly for academic and scientific purposes. Respondents also had the right to withdraw from the study at any

stage without any consequences for their medical care or follow-up services.

## Results

### Sociodemographic Characteristics

Table 1 shows the distribution of participants according to sex. There were 125 (62%) male respondents and 75 (38%) female respondents, giving a male predominance among the study population.

Figure 1 shows the distribution of respondents according to age group. The majority of respondents were aged above 60 years, representing 63% of the study population, followed by those aged 51–60 years (30%), while respondents aged 40–50 years represented only 7%.

**Table 1.** Distribution of Participants According to Sex

| Sex | Frequency (n=200) | Percentage (%) |
|---|---|---|
| Male | 125 | 62 |
| Female | 75 | 38 |
| **Total** | **200** | **100** |

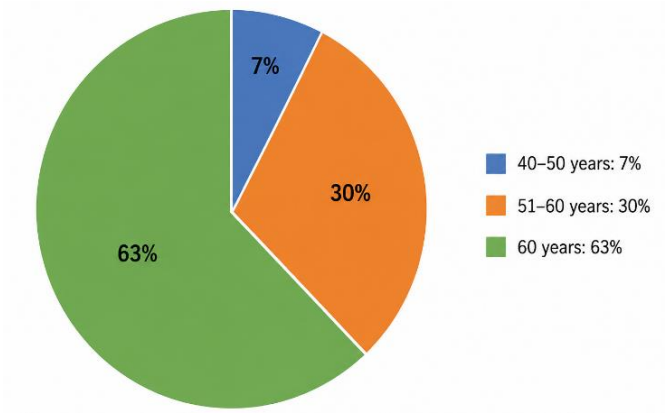


**Figure 1.** Distribution of Participants According to Age Group

### Nutritional Factors Influencing T2DM Management

Table 2 shows the distribution of respondents according to their usual feeding habits. There were 65 (32.5%) respondents who mainly consumed couscous, 60 (30%) who consumed mixed diets, and 54 (27%) who regularly consumed rice. Only 21 (10.5%) respondents reported regular consumption of plantain and vegetables.

**Table 2.** Distribution of Respondents According to Usual Feeding Habits

| Feeding Habit | Frequency | Percentage (%) |
|---|---|---|
| Couscous | 65 | 32.5 |
| Rice | 54 | 27 |
| Mixed Diet | 60 | 30 |
| Plantain and vegetables | 21 | 10.5 |
| **Total** | **200** | **100** |

Table 3 shows the distribution of respondents according to alcohol consumption. There were 68 (34%) respondents who reported regular alcohol consumption, whereas 132 (66%) indicated that they did not consume alcohol regularly.

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**Table 3.** Distribution of Respondents According to Alcohol Consumption

| Alcohol Consumption | Frequency | Percentage (%) |
|---|---|---|
| Yes | 68 | 34 |
| No | 132 | 66 |
| **Total** | **200** | **100** |

Figure 2 presents respondents according to snacking habits between meals. More than half of the respondents (55%) reported regular snacking between meals, while 45% indicated that they did not snack regularly.

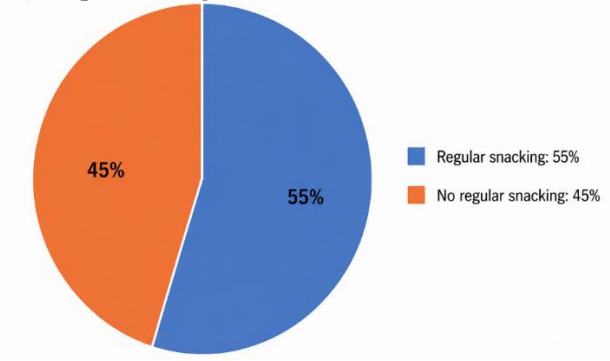


**Figure 2.** Respondents According to Snacking Habits between Meals

## Communication and Educational Factors

Table 4 shows the participation of respondents in educational programs related to type 2 diabetes. There were 162 (81%) respondents who had previously participated in diabetes education programs, while 38 (19%) had never participated in any educational session concerning diabetes management.

**Table 4.** Participation in Educational Programs on Type 2 Diabetes

| Participation in Diabetes Education | Frequency | Percentage (%) |
|---|---|---|
| Yes | 162 | 81 |
| No | 38 | 19 |
| **Total** | **200** | **100** |

Figure 3 shows the preferred communication channels for obtaining information on diabetes management. Healthcare personnel constituted the principal source of information for 45% of respondents, followed by radio/television (20%), family members (18%), and social media platforms (17%).

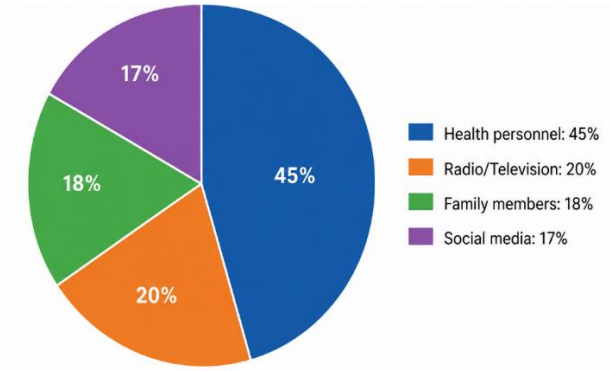


**Figure 3.** Preferred Communication Channels for Diabetes Information

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Table 5 shows respondents' perception of healthcare personnel. There were 126 (63%) respondents who perceived healthcare workers as inaccessible or aggressive, whereas only 74 (37%) considered healthcare personnel accessible and supportive.

**Table 5.** Respondents' Perception of Healthcare Personnel

| Perception | Frequency | Percentage (%) |
|---|---|---|
| Accessible and supportive | 74 | 37 |
| Inaccessible/aggressive | 126 | 63 |
| **Total** | **200** | **100** |

## Socioeconomic Factors

Table 6 shows respondents' perception regarding the cost of diabetes treatment. The majority of respondents, 148 (74%), considered treatment expensive, while only 52 (26%) perceived treatment costs as affordable.

**Table 6.** Respondents According to Perceived Cost of Treatment

| Perception of Cost | Frequency | Percentage (%) |
|---|---|---|
| Affordable | 52 | 26 |
| Expensive | 148 | 74 |
| **Total** | **200** | **100** |

Figure 4 presents the different sources of financing for diabetes treatment. Personal income constituted the main source of treatment financing for 52% of respondents, followed by family support (30%), loans or other means (10%), and health insurance coverage (8%).

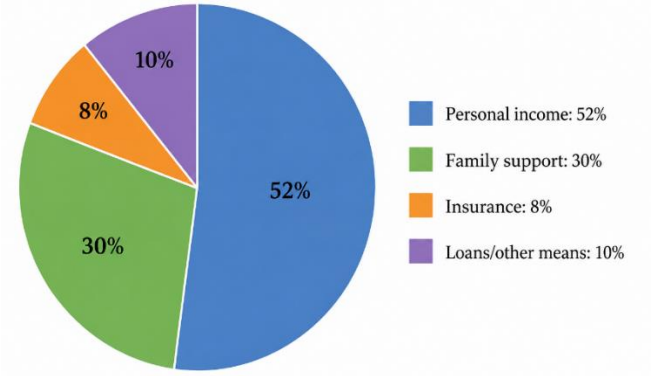


**Figure 4.** Sources of Financing for Treatment

## Medication and Therapeutic Adherence

Table 7 shows the duration of diabetes among respondents. There were 120 (60%) respondents who had been living with diabetes for more than two years, while 52 (26%) had been diabetic for one to two years and 28 (14%) for less than one year.

**Table 7.** Duration of Diabetes among Respondents

| Duration of Illness | Frequency | Percentage (%) |
|---|---|---|
| Less than 1 year | 28 | 14 |
| 1–2 years | 52 | 26 |
| More than 2 years | 120 | 60 |
| **Total** | **200** | **100** |

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Table 8 shows the interruption of treatment among respondents. A very high proportion of respondents, 162 (81%), reported having interrupted treatment at least once, while only 38 (19%) had never interrupted treatment.

**Table 8.** Interruption of Treatment among Respondents

| Treatment Interruption | Frequency | Percentage (%) |
|---|---|---|
| Yes | 162 | 81 |
| No | 38 | 19 |
| **Total** | **200** | **100** |

Figure 5 shows the duration of treatment interruption among respondents who had previously interrupted therapy. Among these participants, 40.7% interrupted treatment for approximately one month, 34% for two to three months, and 25.3% for more than three months.

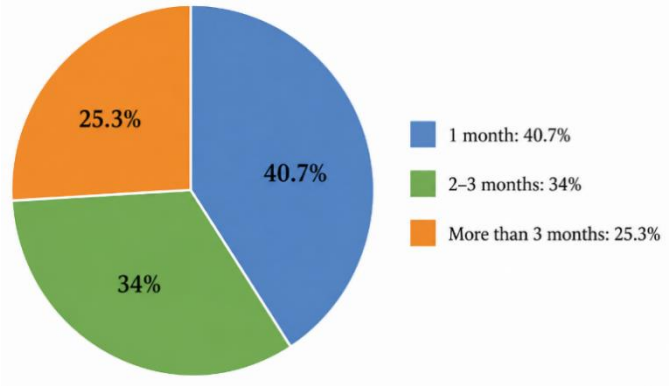


**Figure 5.** Duration of Treatment Interruption

## Discussion

The present study identified several determinants influencing the management of type 2 diabetes mellitus (T2DM) among patients attending the Nylon District Hospital in Douala. The findings highlight the multifactorial nature of diabetes management, involving sociodemographic, nutritional, communication-related, socioeconomic, and therapeutic adherence factors. These determinants collectively contribute to poor glycemic control and increase the risk of diabetes-related complications.

The predominance of male participants (62%) observed in this study may reflect gender differences in healthcare utilization, lifestyle behaviors, and exposure to diabetes risk factors. Similar findings have been reported in studies conducted in sub-Saharan Africa where men were more represented among diabetic patients due to sedentary lifestyles, unhealthy dietary habits, and reduced physical activity [4, 7]. In addition, the majority of respondents were aged above 60 years, confirming that T2DM is more common among older adults. Aging is associated with progressive insulin resistance, reduced pancreatic β-cell function, and increased accumulation of cardiovascular and metabolic risk factors [2, 15]. Comparable observations have been reported by the International Diabetes Federation and WHO, which indicate that the prevalence of T2DM increases significantly with advancing age [1, 3].

Nutritional practices emerged as important determinants of diabetes management in this study. Most respondents consumed carbohydrate-rich foods such as couscous and rice, while only a small proportion regularly consumed fruits and vegetables. Poor dietary habits remain one of the major contributors to poor glycemic control and progression of diabetes complications [8]. Previous studies have demonstrated that diets rich in refined

carbohydrates and low in fiber increase the risk of obesity, hyperglycemia, and cardiovascular complications among diabetic patients [4 ,9]. Furthermore, frequent snacking and poor meal planning may contribute to fluctuations in blood glucose levels, thereby complicating disease management. The findings therefore underscore the importance of reinforcing nutritional counseling and individualized dietary education among diabetic patients.

Alcohol consumption was also relatively high among participants, with approximately one-third of respondents reporting regular alcohol intake. Excessive alcohol consumption has been associated with poor metabolic control, impaired judgment regarding treatment adherence, and increased risk of hypoglycemia or hyperglycemia [8, 10]. Similar studies conducted in Africa have reported that alcohol consumption negatively affects diabetes self-management and contributes to poor therapeutic outcomes [5, 9]. Lifestyle modification, including reduction of alcohol intake, remains a fundamental component of diabetes management and prevention of long-term complications.

Communication and therapeutic education were identified as significant factors influencing diabetes management. Although most respondents had previously participated in educational sessions, nearly one-fifth had never received structured diabetes education. Therapeutic education is essential in enabling diabetic patients to understand their disease, adhere to medications, adopt healthy lifestyles, and recognize warning signs of complications [17, 18]. WHO reports on adherence to long-term therapies emphasize that patient education significantly improves treatment compliance and disease outcomes [16]. Inadequate communication between healthcare professionals and patients may therefore contribute to poor self-care practices and reduced adherence to medical recommendations.

An important finding of this study was that many respondents perceived healthcare personnel as inaccessible or aggressive. Poor patient-provider relationships may discourage patients from attending follow-up consultations and openly discussing their challenges related to disease management. Effective communication between healthcare providers and patients is essential for building trust, encouraging adherence, and improving patient satisfaction [17, 18]. Studies have shown that supportive healthcare environments positively influence diabetes self-management behaviors and improve long-term therapeutic outcomes [16]. The negative perceptions reported in this study therefore suggest the need for improved patient-centered care and communication skills among healthcare providers.

Socioeconomic constraints were also a major obstacle to the effective management of diabetes among participants in this study. Most respondents considered diabetes treatment to be expensive, and many relied on their personal income or family support to pay for it. Diabetes management involves ongoing costs related to medication, laboratory testing, transportation, regular clinical follow-up and dietary changes, which can be difficult for many patients in low-resource settings [6, 11]. Financial difficulties are widely recognized as important factors contributing to poor adherence and treatment discontinuation among diabetic patients in Sub-Saharan Africa [9]. In Cameroon, the growing burden of diabetes and its complications is placing considerable pressure on patients and health systems, especially in urban populations where the prevalence of diabetes continues to rise [13, 14]. Moreover, the lack of universal health coverage and limited health insurance systems further exacerbate this burden in Cameroon and many other developing countries, exposing patients to catastrophic health-care costs and limiting their access to continuous care [12, 14]. Similar observations were reported by Ekoe and Zimmet, who pointed out that socioeconomic inequalities

significantly affect the course of diabetes and access to health services in low- and middle-income countries [15]. According to the World Health Organization, low adherence to long-term treatments among patients with chronic diseases is strongly associated with financial barriers, inadequate care systems, and limited therapeutic education [16]. Therapeutic education and patient empowerment are therefore recommended as essential strategies to improve self-management, treatment adherence and long-term glycaemic control in diabetic patients [17, 18]. Moreover, the International Diabetes Federation estimates that the global burden of diabetes continues to rise rapidly, particularly in developing countries where health resources remain insufficient to ensure adequate management of chronic diseases [19].

A very high proportion of participants (81%) reported treatment discontinuation, indicating low adherence among diabetic patients. Non-adherence to medication is a leading cause of poor glycemic control and is associated with an increased risk of complications such as neuropathy, nephropathy, retinopathy, cardiovascular disease and diabetic foot ulcers [10, 12]. Similar results have been reported in previous studies where financial constraints, insufficient therapeutic education, forgetfulness, poor communication, and a deficient patient-caregiver relationship contributed significantly to treatment discontinuation [4, 16]. In Cameroon and other sub-Saharan African countries, poor adherence to diabetes treatment remains a major public health problem, contributing to increased morbidity, mortality, and healthcare costs [13, 14]. Powers et al. emphasized that therapeutic education of the diabetic patient plays a crucial role in improving adherence and empowering patients to actively participate in managing their disease [17]. Similarly, Funnell and Anderson have reported that patient empowerment and effective communication between healthcare professionals and patients significantly improve treatment outcomes and long-term adherence in people with diabetes [18]. Poor adherence can ultimately lead to higher hospitalization rates, decreased quality of life, worsening chronic complications, and higher mortality in diabetic patients [19].

Overall, the findings of this study emphasize the urgent need for comprehensive interventions aimed at improving diabetes management in Cameroon. Strengthening therapeutic education programs, improving communication between healthcare providers and patients, subsidizing diabetes treatment, and promoting healthy lifestyles could significantly improve adherence and glycemic control. Public health authorities should also reinforce diabetes awareness campaigns and strengthen healthcare systems to ensure accessible and affordable diabetes care for affected populations.

## Conclusion

Type 2 diabetes mellitus remains a major public health challenge in Cameroon. The management of this disease is influenced by several nutritional, socioeconomic, communication-related, and therapeutic factors. Poor dietary practices, alcohol consumption, inadequate communication, high treatment costs, and poor therapeutic adherence were identified as the main barriers to effective management. Strengthening diabetes education programs, improving patient-provider communication, subsidizing treatment costs, and promoting healthy lifestyles could significantly improve disease outcomes and reduce diabetes-related complications.

The findings of this study therefore highlight the need for healthcare personnel to strengthen therapeutic education, communication, and regular patient follow-up, while patients should adhere to dietary recommendations, treatment schedules, and actively participate in diabetes education programs, alongside increased efforts by health authorities to improve the accessibility and affordability of diabetic care,

reinforce screening services, and organize public awareness campaigns on diabetes prevention and management.

## Conflict of Interest

The authors declare no conflict of interest.

## Ethical Approval

Ethical approval for this study was obtained from the Ethics Committee of the University of Douala, Cameroon. Written informed consent was obtained from all participants before data collection.

## Author Contributions

Fankep Dihewou Alphonse Bertin: Conceptualization, Data Collection, Methodology, Formal Analysis, and Project Administration. Christina Mbongueh Mohnchimbare: Original Draft Preparation. Asiati Mbabazi: Review and Editing. Henri Lucien Kamga Fouamno: Supervision.

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## Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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# Consumption of Food Groups During Pregnancy and Adverse Pregnancy Outcomes among Women Attending Public Hospitals in Gambella Town, Southwest Ethiopia

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***Abstract*** *Diets with limited food groups during pregnancy remain a significant predictor of maternal anemia, hypertensive disorders in pregnancy (HDP), preterm delivery (PTD), and low birth weight (LBW). Unbalanced dietary practices remain persistent in low- and middle-income countries, including Ethiopia. This study aimed to compare the risks of adverse pregnancy outcomes between pregnant women who consumed and did not consume specific food groups among women attending public hospitals in Gambella Town, Southwest Ethiopia. An institution-based prospective cohort study was conducted among 254 pregnant women enrolled and followed from July 25, 2024, to March 10, 2025, at public hospitals. Data were collected using a structured questionnaire administered by an interviewer. Food group consumption was assessed twice using a 24-hour dietary recall. Modified Poisson regression models were used to estimate risk ratios and 95% confidence intervals. Of the 254 enrolled women, 232 completed the follow-up (response rate: 91.3%). Lack of consumption of the other vitamin A-rich vegetables, fruit, roots, and tubers was significantly associated with a higher risk of low maternal hemoglobin (ARR = 1.959; 95% CI = 1.073–3.575, P = 0.006). However, HDP, PTD, and LBW were not associated with the consumption of any food groups. Lack of consumption of other vitamin A-rich vegetables, fruits, roots, and tubers was associated with a higher risk of low maternal hemoglobin. Improving antenatal nutrition counseling and education on consuming a variety of food groups, as well as addressing the social determinants that affect intake of food groups, is essential for enhancing pregnancy outcomes.*

***Keywords*** *Adverse Pregnancy Outcomes, Consumption of Food Groups, Gambella, Southwest Ethiopia*

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## Introduction

Suboptimal diets, such as those low in energy and micronutrients, increase the risk of complications during pregnancy and childbirth, weaken the immune system, cause poor fetal growth, and preterm delivery [1, 2]. Optimal dietary intake during preconception and pregnancy can enhance diet quality, gestational weight gain and lead to healthier birth outcomes [1]. Consuming at least five of the ten food groups is associated with greater micronutrient adequacy among women aged 15 to 49 than among those consuming fewer than five [3]. Consumption of maize foods provides limited amounts of lipids and micronutrients, such as vitamins C, A, and E, calcium, salt, and selenium, due to limited dietary diversity, lower nutrient bioavailability, and processing-related nutrient losses [4].

Plant-based foods, whole grains, and dietary fibers indicate carbohydrate quality [5]. Conversely, excessive intake of added sugar and a high sugar-content diet are associated with detrimental health effects [5]. Food groups with high carbohydrates also have detrimental health effects, while enriched and fortified staple foods, such as dairy products and grains, provide critical micronutrients such as calcium, vitamin D, potassium, and dietary fiber [5]. Dietary intake of starchy foods like rice and its byproducts, noodles, and flour products is linked to a higher risk of unfavorable pregnancy outcomes or adverse pregnancy outcomes (APOs), which include preterm delivery (PTD), low birth weight (LBW), maternal anemia, and hypertensive disorders in pregnancy (HDP) [6-9].

Anemia prevalence reached up to 65.9% in Ethiopia [10-15]. The incidence of low birth weight ranged from 9.6% to 41%, and preterm delivery from 9.1% to 38% [16, 17]. The incidence of hypertensive disorders in pregnancy was 6.82% [18].

The high magnitude of diet-associated non-communicable diseases (NCDs) in Ethiopia has been a significant contributor to high mortality and morbidity, posing considerable challenges in both maternal and newborn health, with significant regional and local variations, underscoring the need to understand the interplay between the consumption of food groups and their associated risks of adverse pregnancy outcomes. There is limited evidence on food group consumption and its association with adverse pregnancy outcomes in the Gambella Regional State of Ethiopia, despite more understanding in other regions. Therefore, this study aimed to compare individual food group consumption during pregnancy and examine associated risks of adverse pregnancy outcomes among women attending public hospitals in Gambella Town, Southwest Ethiopia.

## Methods and Materials

### Study Setting and Design

This institution-based prospective cohort study was conducted to compare the risks of HDP, PTD, LBW, and low maternal Hb levels between women with and without practices of consuming each food group during pregnancy among women attending public hospitals in Gambella Town, the capital of Gambella Regional State, located 766 km west of Addis Ababa. The town is in Ethiopia's Western Lowlands at 526 meters above sea level. It is divided into five smallest administrative units, namely Kebele 01, 02, 03, 04, and 05. According to the 2016 Ethiopian Fiscal Year (EFY) or 2023-2024 Gregorian Calendar (GC) population projection, an estimated population of 69,784, including 2,094 pregnant women, resided in the town. The women were enrolled from July 25, 2024, and followed up until March 10, 2025, at two public hospitals, Gambella Town Primary Hospital (GTPH) and Gambella General Hospital (GGH), as in the published articles [19, 20]. The women were followed prospectively to determine mothers'

usual practices of consuming at least one food item twice from each food group during pregnancy and associated risks of adverse pregnancy outcomes.

## Study Population

As described in the published articles [19, 20], the source population comprised pregnant women who were permanent residents of Gambella Town (≥6 months). The target population included all permanent residents aged 15-49 years. The study population consisted of the target population who attended Antenatal Care (ANC) services at GTPH and GGH during the study period. The sample consisted of pregnant women selected from the study population based on predefined inclusion and exclusion criteria.

## Inclusion and Exclusion Criteria

As described in the published articles [19, 20], pregnant women aged 15-49 who were permanent residents of Gambella Town and had a Gestational age (GA) between 12 and 27 completed weeks were eligible for inclusion. Additional inclusion criteria were no known hypertension or blood pressure (BP) < 140/90 mm Hg without any antihypertensive medication, a baseline maternal Hb ≥ 10.0 g/dl, willingness to attend routine ANC visits until delivery at the study hospitals, and provision of written informed consent. Pregnant women with BP<140/90 mm Hg and on any antihypertensive medication or known chronic hypertension under treatment, or those whose delivery was decided or planned outside the study hospitals (e.g., at home or in other facilities) were excluded from the study.

## Sample Size Determination and Sampling Procedures

The sample size was determined using G*Power version 3.1.9.7, written by Franz Faul. To detect a true Relative Risk (RR) or difference in outcome proportions (P1-P2) between the exposed and unexposed groups, Fisher's exact test for two independent groups was used. The calculation assumed a 2-sided test with 85% power (Z 1-β=1.04); a 95% confidence level [Zα/2=1.96], and a type I error rate (α) of 5%. The proportion of inadequate DD practice among the exposed group (P1) was assumed to be 60.2%; the proportion of adequate DD practice among the unexposed group (P2) was 39.8%, yielding an absolute difference of 20.4% and an estimated relative risk of 1.51. An allocation ratio (N2/N1) of 0.66 was applied based on prior evidence among postpartum women in Gambella Town [21]. The DD findings from the postpartum women study were considered a good proxy for DD during pregnancy in this area. After accounting for a 10% non-response rate for potential loss to follow-up, a final sample size of 254 pregnant women was determined.

As described in Wie and colleagues' article [20], this study was conducted in two purposively selected hospitals in Gambella Town. The GTPH and the GGH were selected as the comprehensive ANC and delivery services centers on opposite sides of the Baro River. According to the 2015 EFY (2022-2023 G.C), the two hospitals' reports from the district health information software version 2 (DHIS2) indicated that 528 (71.6%) and 210 (28.4%) pregnant women were registered for their first ANC at GTPH and GGH, respectively. This suggested an average monthly enrollment of 44 and 18 pregnant women for the first ANC services in GTPH and GGH, respectively. Consequently, proportional sample size allocation, based on the number of pregnant women who attended the first ANC, was 182 and 72 for GTPH and GGH, respectively. A facility-based consecutive sampling was used to enroll all eligible pregnant women who attended ANC services at the respective hospitals until the required sample size for each hospital was achieved. Women were reminded regularly of the need to complete. The flow of participants was illustrated (Figure 1).

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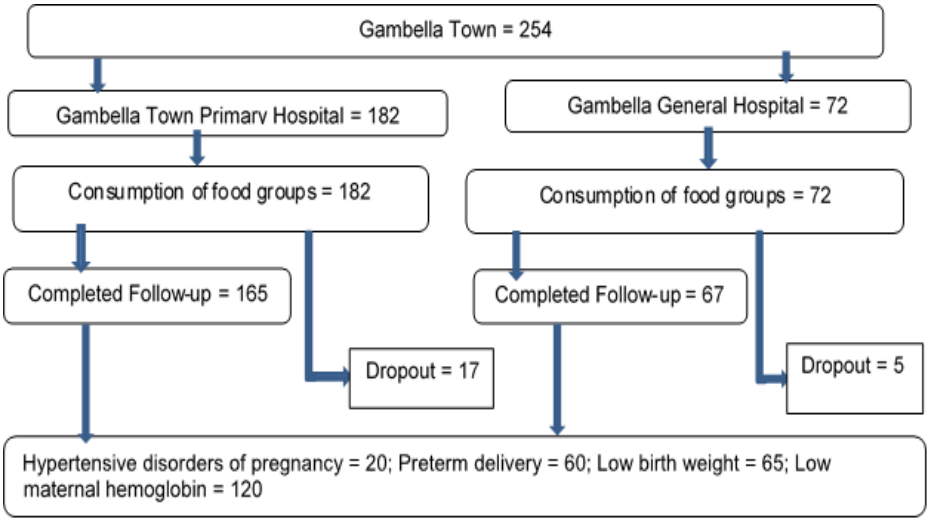


**Figure 1.** Cohort of Pregnant Women Enrolled and Followed up for Exposure in Public Hospitals in Gambella Town, Southwest Ethiopia, 2024-2025

## Study Variables

### Dependent Variable

The dependent variables included pregnancy outcomes, categorized as normal or adverse outcomes. APOs, such as HDP with BP ≥ 140/90 mm Hg with or without positive urine protein, including preeclampsia (PE) or eclampsia, superimposed preeclampsia (SPE), gestational hypertension (GH), chronic hypertension (CH) detected after enrollment, PTD with GA < 37 weeks at birth, LBW with weight < 2500 grams at birth, and low maternal Hb < 10.0 g/dl [20].

### Independent Variables

The primary independent variable was consumption of food groups defined based on consumption of at least one food item twice from the same food groups such as grains; pulses (beans, peas and lentils); nuts and seeds; milk and milk products; meat, poultry and fish; eggs; dark green leafy vegetables; other vitamin A-rich fruits and vegetables; other vegetables; other fruits; fried and salty foods; sweet foods; sugar-sweetened beverages (SSBs); other beverages and foods; red palm oil; other oils and fats; and condiments and seasonings, as per Minimum Dietary Diversity for women (MDD-W) guide.

Other factors confounded the relationship between food group consumption and adverse pregnancy outcomes. These factors were sociodemographic, sociocultural, household socioeconomic status, and individual characteristics [19, 20]. The sociodemographic characteristics included location of residence in Gambella Town; ethnicity; religion; marital relationship; age of the pregnant woman and her partner; education level of a pregnant woman and her partner; occupation types for a woman and her partner; household size and family size; age at the time of her marriage; practices of polygamous marriage by husbands; husband's support of the household with food in kind or cash; number of relatives or visitors in the household; number of children under five years in the household; household income; per capita or average income; household food insecurity and access (HFIA); household economic status based on wealth index quintiles; ownership of seven durable assets [television (TV), fridge, phone, car, bicycle, cheap utensils ≤ 50 United States Dollar (USD) or ≤ 2,750 Ethiopian Birr (ETB), such as a chair, table, clock, watch, water cooker, radio, fan, or mixers, and expensive utensils ≥ 300 USD or ≥ 16,500 ETB, such as a washer, dryer, computer, motorbike, motorboat, air conditioner, or generator as adapted by Wie and his colleagues [19] from standard International

Wealth Index (IWI) scale described by Swits and Steendijk in their 2013 working paper. Other individual characteristics included gravidity; parity; newborn biological sex, acute infectious diseases during pregnancy (e.g., malaria, urinary tract infection (UTI), sexually transmitted infections (STIs), intestinal worms, intestinal parasites); acute non-infectious illnesses (e.g., dyspepsia or gastritis, excessive nausea or vomiting or hyperemesis gravidarum); regular physical activity or exercise or household chores for at least 30 minutes daily; slept under long lasting insecticide treated bed net (LLIN); ever utilized iron and folic acid supplements (IFAS) during pregnancy; dietary habits of taking coffee or tea immediately after meals, alcohol intake, smoking, and charcoal/soil intake during pregnancy as described by Wie and colleagues [19, 20]. Anthropometric indicators were also assessed, including maternal weight before and during pregnancy, height, body mass index (BMI), and mid-upper arm circumference (MUAC), as described by Wie and colleagues [19, 20].

## Data Collection Instruments and Procedures

A structured data collection tool (questionnaire) was administered by an interviewer during data collection. This tool has five components: (I) Baseline characteristics (sociodemographics, sociocultural, household socioeconomic, individual characteristics); (II) MDD-W; (III) HFIA; (IV) Anthropometric, laboratory, and clinical measurements; and (V) Follow-up and outcomes assessments as described by Wie and colleagues [19, 20].

## Gestational Age and Enrollment into the Study

Firstly, GA was determined using either the date of the last normal menstrual period (LNMP) or an obstetric ultrasound that confirmed a viable pregnancy. GA, in accordance with the World Health Organization (WHO), can be based on ultrasound before the 24th week of gestation [22]. Eligible participants were enrolled during their first and second ANC visits.

## Baseline Characteristics Assessment

Baseline data were socio-demographics, socio-cultural characteristics, socioeconomic characteristics, and individual characteristics. The IWI scale was used for the household wealth index. This scale has 12 assets and 20 indicators. These indicators included ownership of consumer durable assets (7 indicators), housing quality characteristics (9 indicators, including floor quality, quality of toilet facilities, and number of rooms for sleeping), and households' access to two basic public utilities (4 indicators), such as access to quality potable water supply and electricity, as adapted by Wie and his colleagues [19] from the standard International Wealth Index (IWI) scale described by Swits and Steendijk in their 2013 working paper.

## Assessment of Consumption of Food Groups

The consumption of each food group was assessed among women of reproductive age twice during enrollment and subsequent visits, one month apart, using two 24-hour (day and night) dietary recall assessments. The two assessments were preferred over a single dietary recall to ensure reliable data on mothers' usual dietary practices of consuming each food group during pregnancy. Foods eaten by pregnant women within 24 hours before the assessment were recorded as breakfast, lunch, dinner, mid-morning snacks, mid-afternoon snacks, and bedtime snacks, regardless of quantity and quality. The principal investigator (PI) ensured that each food item was classified into its appropriate food group according to the MDD-W guide [3]. The ten main food groups assessed included: Grains/cereals; pulses (beans, peas, and lentils); nuts and seeds; dairy (milk and milk products); meat, poultry, and

fish; eggs; dark green leafy vegetables; vitamin A-rich fruits and vegetables; other vegetables; and other fruits [3]. Additional food groups assessed included: Red palm oils; other source oils; fried, savory, and salty foods; sweet foods; sugar-sweetened beverages (SSB); other beverages and foods; condiments and seasonings, such as chili peppers, garlic, ginger root, bean paste, fermented bean paste, tomato paste, and other small food items as per the MDD-W guide [3]. These food groups were assessed for their potential relationships with the risk of adverse pregnancy outcomes. A food group was consumed when at least one food item from the group was eaten twice during two 24-hour dietary recall periods.

## Household Food Insecurity Status Assessment

The food insecurity status of the households was assessed using nine standard questions from the Household Food Insecurity and Access Scale (HFIAS), developed by the Food and Nutrition Technical Assistance (FANTA) in 2007.

## Anthropometry, Clinical Assessments, and Laboratory Tests

As described by Wie and colleagues [19, 20], maternal Hb concentration was measured in grams per deciliter (g/dl) using a HemoCue (Hb analyzer) to determine Hb level. Anthropometric measurements, including maternal height and weight, were collected using standard tools. Maternal height was measured with a stadiometer in the Frankfort standing position and recorded to the nearest 1 mm or 0.1 cm. The maternal weight was measured using a calibrated weighing scale and recorded to the nearest 0.1 kilogram. Calibration of the weight scale was done with an object of known weight. The newborn's weight was measured using an electronic weighing scale and recorded to the nearest 0.1 kilogram. A newborn's weight was measured as follows: the weight of dry linen was measured first. The reading of the dry, warm linen weight was recorded. Then the measurer reset the scale to zero (0). Then the newborn, without clothes, was placed on top of the linen, and the combined newborn and linen weight readings were obtained. Finally, the weight of the linen was subtracted from the weight of the linen plus newborn for the weight of the newborn and recorded to the nearest 100 g.

Mid-upper arm circumference was measured using MUAC tape or an armband, and the reading was to the nearest 0.1 cm. Blood pressure was measured with a digital BP measuring device, specifically an automatic sphygmomanometer. Cuffs were wrapped around the upper arm (left or right) at heart level after the subject rested for at least 5 minutes. Blood pressure was measured in millimeters of Mercury (mmHg) twice in a seated position at an interval of one to two minutes, and the average value of systolic blood pressure (SBP) in mmHg or diastolic blood pressure (DBP) in mmHg was recorded as per the procedure of Takagi and colleagues [23]. When high BP was detected, pregnant women's urine was checked for significant protein levels using a urine dipstick kit. Changes in color readings were compared against the standard. Proteinuria (protein in urine) was confirmed when a dipstick test result of a positive (1+) or higher was detected at least twice during the visit [24].

## Follow-up Assessments

As described by Wie and colleagues [19, 20], pregnant women underwent at least three follow-up visits before the expected date of confinement (EDC) was reached at term (37 completed weeks to 41 completed weeks plus six days). The baseline characteristics, MUAC, weight, and height, were assessed once during enrollment. Consumption of each food group was assessed twice, one month apart. The Hb, BP, and urine protein were checked at every ANC visit. Blood pressure and urine protein were also checked during delivery and within

the first 24 hours after delivery. The newborn's weight was checked at delivery and within the first 24 hours after birth. Pregnancy outcomes were classified as normal pregnancy outcomes or APOs, such as low maternal Hb, HDP, PTD, and LBW. Maternal Hb levels were assessed during ANC follow-up after enrollment until the third trimester of pregnancy or just before delivery. The outcomes, such as presence or absence of PTD, LBW, low maternal Hb levels, and HDP, were assessed during ANC follow-up after enrollment, during delivery, and within 24 hours of delivery. HDP included GH, PE, SPE, and CH, reported but undetected at enrollment. Finally, pregnant women who dropped out or were lost to follow-up or transferred to other facilities before outcomes assessment or died from causes unrelated to the outcomes of interest were excluded from the analysis.

## Data Quality Control

As described by Wie and colleagues [19, 20], the questionnaire was prepared in English, translated into Amharic and Nuer, and back-translated to English by blinded translators to ensure consistency and clarity. Discrepancies were reviewed and resolved through consensus. Six data collectors (midwives and nurses) with Bachelor of Science (BSc) degrees were recruited, along with two supervisors with Master of Science (MSc) degrees.

Data collectors and supervisors received training over three days covering eligibility, skip patterns, dietary recall assessment, follow-up procedures, ethics, and proper use of instruments (digital scales, stadiometers, MUAC tapes, HemoCue Hb analyzers, urine dipstick kits, and automated digital BP devices). They were also trained to use KoboCollect (Android software) for data entry and to assess dietary intake using MDD-W guidelines, portion size with household utensils (e.g., tablespoons, teaspoons, and cups), gram conversion, and food group classification based on the Ethiopian food-based dietary guideline.

Weight scales were calibrated daily. BP was measured twice to obtain average readings. Laboratory quality assurance procedures included cross-checking complete blood counts (CBCs), validating HemoCue Hb readings, and repeating urine protein tests. Questionnaire sections I and II were pre-tested on 10 pregnant women outside the ANC, Gynecology, and Obstetric units of the two hospitals to assess clarity, question sequence, and data collectors' competence. Feedback from the pre-test was incorporated before data collection. Data collectors were blinded to participants' exposure status (exposed and unexposed); they followed all participants until delivery to minimize bias. Supervisors and the PI conducted regular monitoring and cross-verification of ANC and laboratory records to ensure data quality.

## Data Processing and Analysis

Data were collected electronically using KoboCollect version 2024.1.3 and exported to the Statistical Package for the Social Sciences (SPSS) version 25 for data transformation and analysis. Descriptive analyses were performed to summarize the study population and key variables using frequency distributions, percentages, means, and standard deviations. Categorical variables were presented using tables, while continuous variables were summarized using means with standard deviations (SD).

Bivariable modified Poisson regression was conducted to assess associations and identify potential predictors of HDP, low maternal Hb, PTD, and LBW. Risk Ratio (RR), along with the corresponding 95% Confidence Interval (CI), was calculated, and variables with $p < 0.25$, potential confounders, and clinically relevant variables were included in multivariable analysis.

Multivariable regression models with robust standard errors were employed to identify independent predictors while adjusting for confounders. An adjusted Risk Ratio (ARR), along with 95% CI, was calculated to quantify

the strength of associations. Statistical significance was declared at p-value < 0.05 and a 95% CI that excluded unity. Adequacy of models was assessed using deviance statistics or Pearson's chi-square goodness-of-fit tests. Multicollinearity was evaluated using the Variance Inflation Factor (VIF) ≤ 5.

## Operational Definitions

**Food Group Consumption:** A food group was considered consumed when a pregnant woman ate at least one food item from that specific food group in an adequate quantity of at least 15 grams or 1 tablespoon for the 10 food groups of MDDS as per the guide of MDD-W of reproductive age group, or any amount for other food groups, on two occasions from 24 hours before enrollment into study until 24 hours before the second dietary recall assessments; otherwise, it was considered as not consumed food group even if food items were taken once during the study period [19].

**Pregnancy outcomes:** Any outcome, including either normal or any of the four diet-related APOs observed among pregnant women or newborns after enrollment in the follow-up until 24 hours after delivery [20].

**Adverse pregnancy outcomes:** The occurrence of at least one of four diet-related complications, such as hypertensive disorders in pregnancy, preterm delivery, low birth weight, or low maternal Hb less than 10.0 g/dl, that can potentially affect health outcomes among pregnant women and/or their newborns, after enrollment in the follow-up until 24 hours after delivery [20].

**Hypertensive disorders in pregnancy:** The occurrence or exacerbation of any of four clinical forms of hypertension for the first time after enrollment until 24 hours after delivery [20].

**Low maternal hemoglobin:** Maternal Hb concentration was considered low Hb < 10.0 g/dl or hematocrit <30.0% at any stage of pregnancy, as the risks of adverse health outcomes among mothers and newborns increased when the blood Hb level decreased below 10.0 g/dl [23].

# Results

## Socio-Demographics and Socio-cultural Characteristics

Of the 254 enrolled pregnant women, 194 were classified as exposed (inadequate DD) and 60 as unexposed (adequate DD). A total of 232 completed follow-ups (91.3% response rate), with 22 (8.7%) lost to home delivery (12), relocation (5), and loss of contact (5). Participants had a mean age of 24.24 years; most were married (97.8%), lived in Kebele 01 (60.3%), and were predominantly Nuer (58.2%) and Christians (95.7%). Most women had at least a secondary education (69.0%) and were homemakers (72.9%), while 45.4% of partners were employed (Table 1).

**Table 1.** Sociodemographics and Sociocultural Characteristics of Pregnant Women Attending Public Hospitals in Gambella Town, Southwest Ethiopia, 2024–2025

| Variables | Number (n) | Percent (%) |
|---|---|---|
| **Pregnant women age group** | | |
| 16-23 years | 112 | 48.3 |
| 24-38 years | 120 | 51.7 |
| **Marital relationship** | | |
| Married and lived together | 227 | 97.8 |
| Others* | 5 | 2.2 |
| **Partner's age group** | | |
| 17-31 years | 107 | 47.1 |
| 32-60 years | 120 | 52.9 |

| | | |
|---|---|---|
| **Residence location in Gambella Town** | | |
| Kebele 01 | 140 | 60.3 |
| Kebele 02-05 | 92 | 39.7 |
| **Ethnic groups** | | |
| Nuer | 135 | 58.2 |
| Amhara | 23 | 9.9 |
| Oromo | 23 | 9.9 |
| Anuak | 20 | 8.6 |
| Others** | 31 | 13.4 |
| **Religious groups** | | |
| Christianity*** | 222 | 95.7 |
| Islam and Baba John | 10 | 4.3 |
| **Pregnant women's educational level** | | |
| No formal class at the Primary level (Grades 1-8) | 72 | 31.0 |
| At least the secondary education level (Grades 9-12) | 160 | 69.0 |
| **Partner's educational level** | | |
| No formal class at the secondary level (Grades 9-12) | 83 | 36.6 |
| At least a diploma or certificate level | 144 | 63.4 |
| **Pregnant women's occupational types** | | |
| Homemakers | 169 | 72.9 |
| Employed (Government, UN, and NGOs) | 30 | 12.9 |
| Trading, Daily laboring, and Farming | 33 | 14.2 |
| **Partner's occupational types** | | |
| Employed (Government, UN, and NGOs) | 103 | 45.4 |
| Trading, Daily laboring, Farming, and no formal Job | 124 | 54.6 |
| **Family size or family members** | | |
| 1-2 persons | 72 | 31.0 |
| 3-11 persons | 160 | 69.0 |
| **Number of children under 5 years of age among family members in the household** | | |
| No child under five | 112 | 48.3 |
| At least 1 child under five | 120 | 51.7 |
| **Number of relatives/ visitors at home within the month of dietary assessment** | | |
| Less than 2 persons | 105 | 45.3 |
| 2 persons and above | 127 | 54.7 |
| **Household size (family and relatives/visitors) at home within the month of dietary assessment** | | |

| | | |
|---|---|---|
| Less than 5 persons | 110 | 47.4 |
| 5 persons and above | 122 | 52.6 |
| **Partner's polygamy practices in the community** | | |
| Yes | 40 | 17.9 |
| No | 184 | 82.1 |
| **Pregnant women in the age group at the time of their marriage** | | |
| 14-17 years | 63 | 27.2 |
| 18-28 years | 169 | 72.8 |
| **Partner's support of the household with food, either in kind or cash** | | |
| Yes | 189 | 83.3 |
| No | 38 | 16.7 |

*Notes: * Cohabiting, Separated, and Never lived together; ** Kambata, Tigre, Gurage, Gamo, Hadiya, Dawro, Kaffa, Cheka, Welayta, Oppo, and Shilluk; *** Protestant, Orthodox, Seventh-day Adventist, Church of God, Catholic, and Messianic Jewish*

*UN United Nations; NGOs non-governmental Organizations*

## Household Socio-economics and Individual Characteristics

Most participants were multigravida (63.8%), with nearly one-third (32.8%) being multiparous. Based on MUAC, 19.0% of the pregnant women were undernourished, while 7.0% were overnourished before pregnancy. The majority of households (75.9%) were moderately to severely food-insecure, with only 24.1% food-secure and mildly food-insecure (Table 2).

**Table 2.** Household Socioeconomics and Individual Characteristics of Pregnant Women Attending Public Hospitals in Gambella Town, Southwest Ethiopia, 2024–2025

| Variables | Number (n) | Percent (%) |
|---|---|---|
| **Gravidity** | | |
| Primigravida | 84 | 36.2 |
| Multigravida | 148 | 63.8 |
| **Parity** | | |
| Nulliparous and primiparous | 156 | 67.2 |
| Multiparous | 76 | 32.8 |
| **Biological sex of the Newborn** | | |
| Female | 120 | 51.7 |
| Male | 112 | 48.3 |
| **Fatness based on pre-pregnancy body mass index in kilograms per square meter.** | | |
| Normal (18.5-24.5) | 117 | 63.2 |
| Underweight (< 18.5) | 55 | 29.7 |
| Overnutrition (≥ 25.0) | 13 | 7.0 |
| **Maternal fatness based on body mass index in kilograms per square meter** | | |
| Normal (18.0-24.5) | 150 | 64.7 |
| Underweight (< 18.5) | 49 | 21.1 |
| Overnutrition (≥25.0) | 33 | 14.2 |
| **Maternal undernutrition based on mid-upper arm circumference below 23 cm** | | |
| Yes | 44 | 19.0 |
| No | 188 | 81.0 |

| | | |
|---|---|---|
| **Household average income or per capita income** | | |
| < 1250 Birr | 88 | 37.9 |
| ≥ 1240 Birr | 144 | 62.1 |
| **Household food insecurity level** | | |
| Food secure and mildly food insecure | 56 | 24.1 |
| Moderately and severely food insecure | 176 | 75.9 |
| **Household wealth index quintiles.** | | |
| 1st & 2nd quintiles (poorest 20% with the lowest wealth & poor) | 105 | 45.3 |
| 3rd-5th quintiles (middle, rich, & richest 20% with the highest wealth) | 127 | 54.7 |
| **Households with at least two sleeping rooms** | | |
| Yes | 144 | 62.1 |
| No | 88 | 37.9 |
| **Had ever used iron and folic acid supplements for at least 90 days** | | |
| Yes | 99 | 42.7 |
| No | 133 | 57.3 |
| **Physical activities, exercise, or household chores were conducted for at least 30 minutes daily.** | | |
| Yes | 127 | 54.7 |
| No | 105 | 45.3 |
| **Slept under a long-lasting insecticide-treated bed net** | | |
| Yes | 122 | 95.7% |
| No | 10 | 4.3% |
| **Malaria attack confirmed with laboratory tests.** | | |
| Yes | 99 | 42.7 |
| No | 133 | 57.3 |
| **Had anemia in the past pregnancy** | | |
| Yes | 41 | 17.7 |
| No | 191 | 82.3 |
| **Urinary tract and/or sexually transmitted infections** | | |
| Yes | 46 | 19.8 |
| No | 186 | 80.2 |

## Consumption of Food Groups during Pregnancy and Hypertensive Disorders in Pregnancy

After adjusting for potential confounders in this study, there was no significant difference observed in the risks of HDP between pregnant women with and without consumption of food items from food groups such as pulses (ARR = 0.623; 95% CI: 0.208–1.869; p = 0.398) and sugar sweetened beverages (ARR = 2.022; 95% CI: 0.771–5.303; p = 0.152) during pregnancy. The age group of pregnant women between 16 and 23 years showed a significantly reduced risk of hypertensive disorders of pregnancy (HDP), with an 88.5% decrease compared to the age group of 24 to 38 years (Adjusted Risk Ratio [ARR] = 0.115, 95% Confidence Interval [CI]: 0.023–0.581, P = 0.009). Additionally, women residing in Kebele 01 had an 86.9% lower risk of developing HDP compared to

those living in the other four Kebeles (02, 03, 04, and 05) in Gambella Town (ARR = 0.131, 95% CI: 0.024–0.720, P = 0.019). Furthermore, nulliparous women had a 2.1-fold higher risk of HDP compared to those who were at least primiparous (ARR = 3.136, 95% CI: 1.130–8.700, P = 0.028) in this study. (Table 3).

**Table 3.** Hypertensive Disorders in Pregnancy between Women with and without Consumption of Food Groups during Pregnancy among Women Attending Public Hospitals in Gambella Town, 2024–2025

| Variables | Hypertensive Disorders in Pregnancy (n = 232) | | RR (95%CI) | ARR (95%CI) |
|---|---|---|---|---|
| | Yes | No | | |
| **Pulses (beans, lentils, and peas) were consumed.** | | | | |
| No | 10 (6.5%) | 145 (93.5%) | 0.50 (0.22–1.14)* | 0.62 (0.21–1.87) |
| Yes | 10 (13.0%) | 67 (87.0%) | 1 | 1 |
| **Sugar-sweetened beverages (SSBs) were consumed.** | | | | |
| Yes | 10 (9.6%) | 94 (90.4%) | 1.23 (0.53–2.84) | 2.02 (0.77–5.30)* |
| No | 10 (7.8%) | 118 (92.2%) | 1 | 1 |
| **Pregnant women's age group** | | | | |
| 16-23 years | 6 (5.4%) | 106 (94.6%) | 0.46 (0.18–1.15)* | 0.12 (0.02–0.58)** |
| 24-38 years | 14 (11.7%) | 106 (88.3%) | 1 | 1 |
| **Pregnant women's residence in Gambella Town** | | | | |
| Kebele 01 | 7 (5.0%) | 133 (95.0%) | 0.35 (0.15–0.85)** | 0.13 (0.02–0.72)** |
| Kebele 02, 03, 04 & 05 | 13 (14.1%) | 79 (85.9%) | 1 | 1 |
| **Ethnic group origin** | | | | |
| Lowland | 10 (6.4%) | 147 (93.6%) | 0.48 (0.21–1.10)* | 2.15 (0.66–7.00)* |
| Highland | 10 (13.3%) | 65 (86.7%) | 1 | 1 |
| **Pregnant women's educational level** | | | | |
| Informal to Primary | 6 (8.3%) | 66 (91.7%) | 0.95 (0.38–2.38) | 0.40 (0.11–1.50)* |
| Secondary and above | 14 (8.8%) | 146 (91.2%) | 1 | 1 |
| **Parity** | | | | |
| Nulliparous | 11 (11.5%) | 85 (88.5%) | 1.73 (0.75–4.02)* | 3.14 (1.13–8.70)** |
| At least primiparous | 9 (6.6%) | 127 (93.4%) | 1 | 1 |
| **Body mass index during the pre-pregnancy state** | | | | |
| Under & overnutrition | 8 (6.8%) | 109 (93.2%) | 0.78 (0.28–2.14) | 0.36 (0.12–1.11)* |
| Normal | 6 (8.8%) | 62 (91.2%) | 1 | 1 |
| **Regular physical activity and exercise, or household chores, for at least 30 minutes daily.** | | | | |
| No | 6 (5.7%) | 99 (94.3%) | 0.52 (0.21–1.30)* | 3.26 (0.88–12.07)* |
| Yes | 14 (11.0%) | 113 (89.0%) | 1 | 1 |
| **Household economic status using wealth index quintiles** | | | | |
| 1st to 2nd Quintiles | 13 (12.4%) | 92 (87.6%) | 2.25 (0.93–5.43)* | 2.06 (0.69–6.16)* |
| 3rd to 5th Quintiles | 7 (5.5%) | 120 (94.5%) | 1 | 1 |

*Notes: * P-value < 0.25; ** P-value < 0.05; RR, risk ratio; ARR, adjusted risk ratio; CI, confidence interval*

## Consumption of Food Groups During Pregnancy and Low Maternal Hemoglobin

Among 232 pregnant women who completed the follow-up periods and delivered in the two hospitals in Gambella Town, 111 (56.6%) pregnant women did not consumed food items from vitamin A-rich roots, tubers, vegetables, and fruits developed low Hb level less than 10.0 g/dl during pregnancy and 9 (25.0%) pregnant women who consumed food items from vitamin A-rich roots, tubers, vegetables, and fruits developed low hemoglobin less than 10.0 g/dl during pregnancy.

A modified Poisson regression model with a log link and robust standard errors was used to compare the risk of low hemoglobin levels among pregnant women who consumed different food groups and those who did not. After adjusting for confounders, the risk of low maternal Hb level among pregnant women without consumption of food items from vitamin A-rich roots, tubers, vegetables, and fruits was 95.6% higher than among their counterparts (ARR = 1.959; 95% CI = 1.073–3.575, P = 0.006). There was no significant difference in risk of low Hb level < 10.0 g/dl between pregnant women with and without consumption of food items from food groups, such as pulses (ARR = 1.115; 95% CI = 0.797–1.539, P = 0.529); milk and milk products (ARR = 0.922; 95% CI = 0.660–1.287, P = 0.632); meats, poultry and fish (ARR = 0.915; 95% CI = 0.714–1.173, P = 0.485); dark green leafy vegetables (ARR = 0.869; 95% CI = 0.663–1.139, P = 0.310); other vegetables (ARR = 0.904; 95% CI = 0.701–1.166, P = 0.437), and other fruits (ARR = 1.968; 95% CI = 0.962–4.027, P = 0.064) in this study. The risk of low hemoglobin < 10.0 g/dl among pregnant women was significantly associated with residence in five kebeles of Gambella Town. Pregnant women living in Kebele 01 have a 77% higher risk of developing low hemoglobin (Hb) during pregnancy compared to those residing in other kebeles (02, 03, 04, and 05) in Gambella Town (Table 4).

**Table 4.** Low Maternal Hemoglobin between Women with and without Consumption of Food Groups during Pregnancy among Women Attending Public Hospitals in Gambella Town, 2024–2025

| Variables | Low maternal Hb (n = 232) | | RR (95%CI) | ARR (95%CI) |
|---|---|---|---|---|
| | Yes | No | | |
| **Pulses (beans, lentils, and peas) were consumed.** | | | | |
| No | 88 (56.8%) | 67 (43.2%) | 1.37 (1.01–1.84)** | 1.12 (0.80–1.54) |
| Yes | 32 (41.6%) | 45 (58.4%) | 1 | 1 |
| **Milk and milk products were consumed.** | | | | |
| No | 105 (52.2%) | 96 (47.8%) | 1.08 (0.73–1.59) | 0.92 (0.66–1.29) |
| Yes | 15 (48.4%) | 16 (51.6%) | 1 | 1 |
| **Meats, poultry, and fish were consumed.** | | | | |
| No | 64 (51.2%) | 61 (48.8%) | 0.98 (0.76–1.26) | 0.92 (0.71–1.17) |
| Yes | 56 (52.3%) | 51 (47.7%) | 1 | 1 |
| **Dark green leafy vegetables were consumed.** | | | | |
| No | 84 (47.7%) | 92 (52.3%) | 0.74 (0.58–0.95)** | 0.87 (0.66–1.14) |
| Yes | 36 (64.3%) | 20 (35.7%) | 1 | 1 |
| **Vitamin A-rich roots, tubers, vegetables, and fruits were consumed.** | | | | |
| No | 111 (56.6%) | 85 (43.4%) | 2.27 (1.27–4.04)** | 1.96 (1.07–3.58)** |
| Yes | 9 (25.0%) | 27 (75.0%) | 1 | 1 |
| **Other vegetables were consumed.** | | | | |

| | | | | |
|---|---|---|---|---|
| No | 46 (49.5%) | 47 (50.5%) | 0.93 (0.72–1.20) | 0.90 (0.70–1.17) |
| Yes | 74 (53.2%) | 65 (46.8%) | 1 | 1 |
| **Other fruits were consumed.** | | | | |
| No | 113 (57.1%) | 85 (42.9%) | 2.77 (1.42–5.42)** | 1.97 (0.96–4.03)* |
| Yes | 7 (20.6%) | 27 (79.4%) | 1 | 1 |
| **Pregnant women's residence in Gambella Town** | | | | |
| Kebele 01 | 88 (62.9%) | 52 (37.1%) | 1.81 (1.33–2.46)** | 1.77 (1.04–3.03)** |
| Kebele 02, 03, 04 & 05 | 32 (34.8%) | 60 (65.2%) | 1 | 1 |
| **Ethnic group origin** | | | | |
| Lowland | 90 (57.3%) | 67 (42.7%) | 1.43 (1.05–1.95)** | 0.61 (0.34–1.08)* |
| Highland | 30 (40.0%) | 45 (60.0%) | 1 | 1 |
| **Experienced excessive nausea and/or vomiting during pregnancy (Hyperemesis Gravidarum)** | | | | |
| Yes | 44 (53.7%) | 38 (46.3%) | 1.06 (0.82–1.37) | 1.10 (0.87–1.40) |
| No | 76 (50.7%) | 74 (49.3%) | 1 | 1 |
| **Household food insecurity level** | | | | |
| Moderately and severely food insecure | 90 (51.1%) | 86 (48.9%) | 0.96 (0.72–1.27) | 0.76 (0.56–1.03)* |
| Food secure and mildly food insecure | 30 (53.6%) | 26 (46.4%) | 1 | 1 |
| **Iron and folic acid supplements have been used as recommended by healthcare providers.** | | | | |
| No | 82 (61.7%) | 51 (38.3%) | 1.61 (1.21–2.13)** | 1.18 (0.89–1.56)* |
| Yes | 38 (38.4%) | 61 (61.6%) | 1 | 1 |
| **Household Food Insecurity (FI) level** | | | | |
| Moderate & severe FI | 90 (51.1%) | 86 (48.9%) | 0.96 (0.73–1.30) | 0.80 (0.58–1.10)* |
| Food secure & mild FI | 30 (53.6%) | 26 (46.4%) | 1 | 1 |

*Notes: * P-value < 0.25; ** P-value < 0.05; *** Church of God, Islam/Muslim, and Messianic Jewish; **** Orthodox, Catholic, and Baba John; ***** Nuer, Anuak, Oppo, Shilluk, and Burun; ****** Amhara, Oromo, Kambata, Gurage, Tigre, Gamo, Hadiya, Dawro, Kaffa, Cheka, and Welayta*

*RR, risk ratio; ARR, adjusted risk ratio; CI, confidence interval*

## Consumption of Food Groups during Pregnancy and Preterm Delivery

The risk of PTD was not significantly different between pregnant women with and without consumption of food items from most food groups during pregnancy in this study. There was no significant difference in risk of PTD between pregnant women with and without consumption of food items from food groups, such as pulses (ARR = 0.905; 95% CI = 0.552–1.486, P = 0.694); milk and milk products (ARR = 0.783, 95% CI = 0.432–1.421, P = 0.421); meats, poultry and fish (ARR = 1.149; 95% CI = 0.707–1.868, P = 0.575); eggs (ARR = 1.039; 95% CI = 0.464–2.329, P = 0.926); dark green leafy vegetables (ARR = 1.069; 95% CI = 0.607–1.884, P = 0.816); vitamin A-rich roots, tubers, vegetables and fruits (ARR = 1.238; 95% CI = 0.633–2.420, P = 0.533); other vegetables (ARR = 0.893; 95% CI = 0.573–1.393, P = 0.619), and other fruits (ARR = 1.235; 95% CI = 0.586–2.602, P = 0.578) in this study (Table 5).

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**Table 5.** Preterm Delivery between Women with and without Consumption of Food Groups during Pregnancy among Women Attending Public Hospitals in Gambella Town, 2024–2025

| Variables | Preterm delivery (n = 232) | | RR (95%CI) | ARR (95%CI) |
|---|---|---|---|---|
| | Yes | No | | |
| **Pulses (beans, lentils, and peas) were consumed** | | | | |
| No | 38 (24.5%) | 117 (75.5%) | 0.86 (0.55–1.34) | 0.91 (0.55–1.49) |
| Yes | 22 (28.6%) | 55 (71.4%) | 1 | 1 |
| **Milk and milk products were consumed** | | | | |
| No | 51 (25.1%) | 150 (74.6%) | 0.87 (0.48–1.59) | 0.78 (0.43–1.42) |
| Yes | 9 (29.0%) | 22 (71.0%) | 1 | 1 |
| **Meats, poultry, and fish were consumed** | | | | |
| No | 35 (28.0%) | 90 (72.0%) | 1.20 (0.77–1.87) | 1.15 (0.71–1.87) |
| Yes | 25 (23.4%) | 82 (76.6%) | 1 | 1 |
| **Eggs** | | | | |
| No | 55 (25.7%) | 159 (74.3%) | 0.93 (0.43–2.02) | 1.04 (0.46–2.33) |
| Yes | 5 (27.8%) | 13 (72.2%) | 1 | 1 |
| **Dark green leafy vegetables were consumed** | | | | |
| No | 47 (26.7%) | 129 (73.3%) | 1.15 (0.67–1.97) | 1.07 (0.61–1.88) |
| Yes | 13 (23.2%) | 43 (76.8%) | 1 | 1 |
| **Vitamin A-rich roots, tubers, vegetables, and fruits were consumed** | | | | |
| No | 52 (26.5%) | 144 (73.5%) | 1.19 (0.62–2.30) | 1.24 (0.63–2.42) |
| Yes | 8 (22.2%) | 28 (77.8%) | 1 | 1 |
| **Other vegetables were consumed** | | | | |
| No | 24 (25.8%) | 69 (74.2%) | 1.00 (0.64–1.56) | 0.89 (0.57–1.39) |
| Yes | 36 (25.9%) | 103 (74.1%) | 1 | 1 |
| **Other fruits were consumed** | | | | |
| No | 53 (26.8%) | 145 (73.2%) | 1.30 (0.65–2.62) | 1.24 (0.59–2.60) |
| Yes | 7 (20.6%) | 27 (79.4%) | 1 | 1 |
| **Experienced a urinary tract infection and/or sexually transmitted infections** | | | | |
| Yes | 8 (17.4%) | 38 (82.6%) | 0.62 (0.32–1.22)* | 0.63 (0.32–1.25)* |
| No | 52 (28.0%) | 134 (72.0%) | 1 | 1 |
| **Household Food Insecurity (FI) level** | | | | |
| Moderate & severe FI | 41 (23.3%) | 135 (76.7%) | 0.69 (0.44–1.08)* | 0.71 (0.44–1,14)* |
| Food secure & mild FI | 19 (33.9%) | 37 (66.1%) | 1 | 1 |

*Notes: * P-value < 0.25; ** P-value < 0.05; RR, risk ratio; ARR, adjusted risk ratio; CI, confidence interval; Hb, hemoglobin.*

## Consumption of Food Groups during Pregnancy and Low Birth Weight

The risk of LBW among newborns was not significantly different between pregnant women with and without the consumption of food items from most of the food groups during pregnancy. There was no significant difference in risk of LBW among newborns from pregnant women with and without consumption of food items from food groups, such as pulses (ARR = 1.293; 95% CI = 0.813–2.055, P = 0.277); milk and milk products (ARR = 1.371; 95% CI = 0.701–2.683, P = 0.357); meats, poultry and fish (ARR = 1.204, 95% CI = 0.785–1.845, P = 0.395); dark green leafy vegetables

(ARR = 1.026; 95% CI = 0.633–1.664, P = 0.917); vitamin A-rich roots, tubers, vegetables and fruits (ARR = 1.012; 95% CI = 0.547–1.873, P = 0.970), and other vegetables (ARR = 0.644; 95% CI = 0.407–1.018, P = 0.060). There was a significant difference in the risk of LBW with other maternal characteristics during pregnancy. The risk of LBW was 97.6% higher among newborns whose mothers were undernourished during pregnancy (ARR = 1.976; 95% CI = 1.334–2.925, P = 0.001). However, the risk of LBW was 47.9% lower among newborns whose mothers experienced excessive nausea or vomiting (hyperemesis gravidarum) at the early stage of pregnancy (ARR = 0.521; 95% CI = 0.313–0.867, P = 0.012) in this study (Table 6).

**Table 6.** Low Birth Weight between Women with and without Consumption of Food Groups during Pregnancy among Women Attending Public Hospitals in Gambella Town, 2024–2025

| Variables | Low birth weight (n = 232) | | RR (95%CI) | ARR (95%CI) |
|---|---|---|---|---|
| | Yes | No | | |
| **Pulses (beans, lentils, and peas) were consumed** | | | | |
| No | 47 (30.3%) | 108 (69.7%) | 1.30 (0.81–2.07) | 1.29 (0.81–2.06) |
| Yes | 18 (23.4%) | 59 (76.6%) | 1 | 1 |
| **Milk and milk products were consumed** | | | | |
| No | 58 (28.9%) | 143 (71.1%) | 1.28 (0.64–2.54) | 1.37 (0.70–2.68) |
| Yes | 7 (22.6%) | 24 (77.4%) | 1 | 1 |
| **Meats, poultry, and fish were consumed** | | | | |
| No | 36 (28.8%) | 89 (71.2%) | 1.06 (0.70–1.61) | 1.20 (0.79–1.85) |
| Yes | 29 (27.1%) | 78 (72.9%) | 1 | 1 |
| **Dark green leafy vegetables were consumed** | | | | |
| No | 49 (27.8%) | 127 (72.2%) | 0.97 (0.60–1.57) | 1.03 (0.63–1.66) |
| Yes | 16 (28.6%) | 40 (71.4%) | 1 | 1 |
| **Vitamin A-rich roots, tubers, vegetables, and fruits were consumed** | | | | |
| No | 56 (28.6%) | 140 (71.4%) | 1.14 (0.62–2.10) | 1.01 (0.55–1.87) |
| Yes | 9 (25.0%) | 27 (75.0%) | 1 | 1 |
| **Other vegetables were consumed** | | | | |
| No | 20 (21.5%) | 73 (78.5%) | 0.66 (0.42–1.05)* | 0.64 (0.41–1.02)* |
| Yes | 45 (32.4%) | 94 (67.6%) | 1 | 1 |
| **Gestational age was completed at birth** | | | | |
| Preterm | 16 (26.7%) | 44 (73.3%) | 0.94 (0.58–1.52) | 0.95 (0.60–1.50) |
| Term | 49 (28.5%) | 123 (71.5%) | 1 | 1 |
| **Maternal blood hemoglobin level in the 3rd trimester or just before delivery** | | | | |
| < 10 g/dl | 38 (31.7%) | 82 (68.3%) | 1.31 (0.86–2.00)* | 1.32 (0.87–2.00)* |
| ≥ 10 g/dl | 27 (24.1) | 85 (75.9%) | 1 | 1 |
| **Pregnant woman's employment status** | | | | |
| No | 54 (26.7%) | 148 (73.3%) | 0.73 (0.43–1.23)* | 0.65 (0.41–1.04)* |
| Yes | 11 (36.7%) | 19 (63.3%) | 1 | 1 |
| **Undernutrition status using mid-upper arm circumference < 23 cm** | | | | |
| Yes | 20 (45.5%) | 24 (54.5%) | 1.90 (1.26–2.87)** | 1.98 (1.33–2.93)** |
| No | 45 (23.9%) | 143 (76.1%) | 1 | 1 |
| **Excessive nausea and/or vomiting experienced early during pregnancy** | | | | |

| | | | | |
|---|---|---|---|---|
| Yes | 15 (18.3%) | 67 (81.7%) | 0.55 (0.33–0.91)** | 0.52 (0.31–0.87)** |
| No | 50 (33.3%) | 100 (66.7%) | 1 | 1 |
| **Household economic status using wealth index quintiles** | | | | |
| 1st to 2nd Quintiles | 32 (30.5%) | 73 (69.5%) | 1.17 (0.78–1.77) | 1.38 (0.92–2.05)* |
| 3rd to 5th Quintiles | 33 (26.0%) | 94 (74.0%) | 1 | 1 |

*Notes: * P-value < 0.25; ** P-value < 0.05; RR, risk ratio; ARR, adjusted risk ratio; CI, confidence interval*

## Discussion

In this study, there was no significant difference in the risk of HDP between pregnant women who consumed food groups and those who did not. However, residence, maternal age, and parity were the significant predictors of HDP. Pregnant women residing in Kebele 01 experienced a substantially higher risk of HDP. The strong association between residence and adverse pregnancy outcomes, such as HDP and low maternal Hb, suggests an ethnic or racially based distribution of residences by kebeles in the town, with variation in genetics, socioeconomic status, and other social determinants, and disparities in this study setting. This finding is supported by several studies, which highlight that the global, regional, national, and local risks of HDP are explained by variations in genetics and other social determinants [25-27]. In this setting, there is an ethnic-based settlement by Kebeles, with possible variations in genetics, socioeconomic status, and other social determinants of health, which may explain differences in the risk of HDP by residential location. Targeted interventions, such as screening and close monitoring focusing on women from high-risk kebeles, could therefore help in reducing the impact of HDP.

Maternal age was also a significant determinant, with older mothers (24–38 years) being more likely to develop HDP than those younger than 16–23 years. This is inconsistent with evidence showing that adolescent pregnancies are associated with physiological immaturity, nutritional deficiencies, and limited ANC uptake, which increase susceptibility to hypertensive conditions [18, 28]. This finding reinforces the importance of not delaying the first pregnancy beyond the youth age group (age > 24 years). Parity demonstrated a well-established relationship with HDP. Nulliparous women had a markedly higher risk compared to those with prior births [29]. First pregnancies are known to pose a higher risk for preeclampsia and other hypertensive complications due to immunological factors, placental development dynamics, and lack of prior adaptation to pregnancy. This emphasises the need for close monitoring of first-time mothers during ANC visits. Strengthening ANC among younger and first-time expectant mothers for appropriate screening and counseling could be a key strategy for early detection and management of HDP.

This study identified two main predictors of low maternal hemoglobin levels: lack of intake of other vitamin A-rich vegetables, fruits, roots, and tubers, and residence in Kebele 01. Studies in low-resource settings reported that diets low in vitamin A-rich foods were associated with higher rates of anemia among pregnant women [30, 31]. This finding highlights the critical need for other vitamin A-rich vegetables, fruits, roots, and tubers during antenatal nutrition counselling. Disparity in risk of anemia was found with residential location by Kebeles in Gambella Town, with women in Kebele 01 experiencing a higher burden of low maternal Hb. This highlights the geographical and socioeconomic disparities in maternal dietary practices and anemia. Research shows that variations in anemia across different regions are

linked to differences in socioeconomic conditions, food security, and access to a variety of foods, as well as the availability and accessibility of maternal health care services [32-35]. This suggests that women in one area may face higher rates of poor sanitation, malaria exposure, or limited ANC, thereby contributing to lower maternal Hb. This finding suggests targeted community-based interventions, such as nutrition education, micronutrient supplementation, and strengthening ANC services, to address the disparities.

Maternal undernutrition was a significant predictor of LBW. The strong association between low MUAC < 23 cm and LBW aligns with extensive literature linking maternal undernutrition to intrauterine growth restriction (IUGR) [36-38]. Women with MUAC < 23 cm are more likely to have inadequate energy and micronutrient stores, limiting fetal growth and increasing the risk of LBW. This highlights the critical need for routine nutritional assessment during antenatal care and targeted interventions such as maternal supplementation with multiple micronutrients (MMNs) and counselling on balanced diets. An association was observed between excessive nausea and/or vomiting experienced in the early stage of pregnancy and LBW. It is inconsistent with findings in studies that demonstrated excessive nausea or vomiting was considered a risk factor for adverse birth outcomes due to poor maternal intake and dehydration [39, 40]. Possible explanations may include early management and care for nausea or vomiting since fetal weight gain peaks in the early third trimester. Pregnant women with nausea and/or vomiting early in pregnancy may receive more intensive medical attention, dietary counselling and guidance, and closer monitoring, which could mitigate the risk of LBW.

## Conclusion

Lack of consumption of other vitamin A–rich vegetables, fruits, roots, and tubers was a significant independent determinant of a higher risk of low maternal hemoglobin levels. Residence in Kebele 01 was also a significant determinant of a higher risk of low maternal hemoglobin levels. Advanced maternal age (24-38 years), residing in Kebele 01, and being a first-time pregnant woman were found to be predictors of a higher risk of hypertensive disorders in pregnancy (HDP). These findings highlight the necessity for location-specific interventions, greater support for older and first-time pregnant women, and the reinforcement of antenatal care for the early detection and management of hypertension during pregnancy. Strengthening dietary counselling, improving access to diverse foods, and targeting geographically vulnerable women are critical steps to reducing risks of maternal anemia and HDP. Maternal undernutrition during pregnancy was a determinant of a higher risk of LBW. This finding underscores the critical role of screening for nutritional status during ANC. Interventions to improve maternal nutrition, particularly for women with low MUAC, remain essential. Additional studies are needed to investigate the consumption of various foods, sociodemographic factors, sociocultural influences, socioeconomic status, individual characteristics, and adverse pregnancy outcomes.

## Data Availability

The datasets analyzed in this article can be obtained from the corresponding author upon request.

## Conflict of Interest

The authors declare no conflicts of interest.

## Ethics Approval

Ethical clearance and permission were granted by the Gambella Regional Health Bureau Ethical Review Committee, with reference number □□/9888/16 on 02 July 2024, to access data from the two hospitals. Written informed consent was obtained from all participants after telling them the purpose, risks, and benefits. Participants were also told of their right to refuse or withdraw at any time without affecting their services. The inclusion of high-risk groups, such as pregnant women aged 15-49 years, was declared. Finally, confidentiality was strictly maintained.

## Author Contributions

The corresponding author played a pivotal role in the study's conception, design, data acquisition, analysis, interpretation, drafting of the manuscript, and critical revision for significant intellectual content. The corresponding author also submitted the manuscript to the journal and accepts full responsibility for the integrity and accuracy of the work. The co-authors' contributions included scientific guidance, critical review of the manuscript for intellectual content, final approval of the version to be published, and agreement to submit the manuscript to the current journal.

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# The Influence of Multi-stakeholder Health Promotion Interventions on Maternal and Infant Mortality Outcomes in Lagos State, Nigeria

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***Abstract*** *Maternal and infant mortality rates in peri-urban Lagos State, Nigeria, persist at critically elevated levels despite improvements in health infrastructure. In the Epe and Ibeju Lekki Local Government Areas (LGAs), a trust deficit rooted in sociocultural disconnection between formal health systems and community governance structures drives high rates of unbooked deliveries and late-stage obstetric emergencies. This study evaluates the influence of a structured Multi-Stakeholder Health Promotion Intervention (MSHPI) on maternal health service utilization, emphasizing the roles of traditional leaders, religious authorities, male household decision-makers, and narrative media in driving behavioural change. A convergent parallel mixed-methods design was employed. A structured questionnaire was administered to 500 women of reproductive age (15 to 49 years) across Epe and Ibeju Lekki LGAs using multi-stage stratified sampling, with data analyzed via logistic regression and Chi-square tests. Qualitative data from 25 Key Informant Interviews and 4 Focus Group Discussions were analyzed through thematic content analysis. Results revealed that women receiving antenatal care (ANC) counselling endorsed by traditional rulers were 3.42 times more likely to book care in the first trimester (OR = 3.42; 95% CI: 2.15, 5.43; $p < 0.001$). Husband's approval was the strongest individual predictor of skilled birth attendance (OR = 4.42; $p < 0.001$). Exposure to the 'Man of the House' edutainment intervention produced a 68.4% increase in facility-based deliveries ($p = 0.004$). Postnatal care uptake remained critically low at 29.6%. Integrating traditional, religious, and male stakeholders into a coordinated advocacy framework significantly improves health-seeking behaviour, highlighting the value of institutionalizing Community Health Advocacy Councils.*

***Keywords*** *Antenatal Care, Community Health Promotion, Edutainment, Infant Mortality, Lagos State, Maternal Mortality, Multi-stakeholder Interventions, Male Involvement, Nigeria, Trust Infrastructure.*

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## Introduction

The global trajectory of public health is undergoing a decisive transformation, one that moves beyond the metrics of hospital bed density and surgical capacity toward a deeper reckoning with the social, cultural, and relational determinants of health outcomes. Nowhere is this transformation more urgently needed than in sub-Saharan Africa, where maternal and infant mortality rates remain among the highest in the world, and where the failure of conventional clinical strategies to reduce these rates has become undeniable [18, 19, 23].

Nigeria occupies a troubling position at the centre of this crisis. Despite being the continent's largest economy and most populous nation, Nigeria accounts for a disproportionate share of global maternal deaths. Within this national context, Lagos State presents a paradox that is both intellectually compelling and morally urgent. As the country's commercial capital, Lagos possesses the infrastructure, medical personnel, and financial resources that other states lack. Yet in its peripheral LGAs, particularly Epe and Ibeju Lekki, maternal and infant mortality rates persist at levels incompatible with this level of economic development [10, 18, 23].

This paradox demands explanation. The answer, this study argues, lies not in a shortage of facilities but in a chronic deficit of trust. Expectant mothers in these communities do not necessarily distrust medicine; they distrust a health system that has repeatedly failed to communicate with them on their own cultural terms, through the voices they consider authoritative. When a traditional ruler, an Imam, a Pastor, or a husband endorses a health behaviour, the message carries a social legitimacy that a clinical poster or a health talk at the Primary Health Centre (PHC) cannot replicate.

This study investigates the influence of Multi-Stakeholder Health Promotion Interventions (MSHPIs), which are structured frameworks that deliberately engage traditional leaders, religious authorities, male household decision-makers, and narrative media, on maternal and infant health outcomes in Epe and Ibeju Lekki. It does so through a mixed-methods design that combines the statistical rigour of quantitative analysis with the interpretive depth of qualitative inquiry, producing a body of evidence that is both numerically verifiable and contextually meaningful.

## Background

The 2024 Nigeria Verbal and Social Autopsy (VASA) survey identified that more than 60% of maternal deaths in the southwest geopolitical zone were precipitated by Type 1 Delays, which represent delays in the decision to seek care. These are not delays caused by road conditions or clinic opening hours; they are delays caused by the absence of social permission. A woman in Epe waits for her husband's approval. She waits for her mother-in-law's counsel. She waits for her pastor to confirm that hospital birth is spiritually permissible. When these approvals do not come on time, the consequences are fatal [11].

Retrospective analyses of Lagos tertiary facilities consistently demonstrate that unbooked mothers, meaning those who are present at labour without prior ANC contact, face mortality rates many times higher than their booked counterparts. The unbooked status itself is a symptom of the Trust Deficit: a system that has not earned the confidence of the communities it claims to serve [13, 15].

The Epe and Ibeju Lekki LGAs were selected as study sites because they represent the intersection of two realities: rapid economic growth and deeply embedded traditional community governance. These are not remote, resource-deprived localities. They are LGAs connected to Nigeria's most dynamic metropolitan economy, and yet they carry health burdens that mirror far more isolated communities. This makes them an ideal and

urgent case study for understanding what separates infrastructure from impact in Nigerian public health.

## Theoretical Framework

### The Social Ecological Model (SEM)

The Social Ecological Model provides structural architecture for this study. The SEM conceptualizes health behaviour as the outcome of interactions across five nested levels: individual, interpersonal, community, institutional, and policy. Applied to maternal health in peri-urban Lagos, the model reveals that interventions concentrated at the individual level, such as patient education and antenatal counselling, have limited reach when the interpersonal and community layers remain unconfigured for health promotion. In this study, the SEM is operationalized by treating community stakeholders, including traditional rulers, religious leaders, and male household heads, as the interpersonal and community layers through which clinical messages must pass in order to be acted upon. The model predicts, and this study confirms, that aligning these layers dramatically improves the penetration of health-promoting norms [9, 21].

### The Trust Infrastructure Theory

This study introduces the Trust Infrastructure Theory as an original theoretical contribution. Trust Infrastructure is defined as the network of relational validations, social endorsements, and cultural authority structures that determine whether a formal health system is perceived as credible, safe, and worth engaging with. In the absence of robust Trust Infrastructure, clinical facilities may be physically accessible yet socially inaccessible, meaning they are present in the community but absent from the community's confidence.

The theory posits that Trust Infrastructure is not built by the health system alone; it is borrowed from existing community authority systems. When a traditional ruler endorses the PHC, the PHC inherits a portion of the trust already deposited in that ruler over generations. This borrowed legitimacy is quantifiable, as the data in this study demonstrate.

### The Dual-Barricade Model

Factor analysis of the barriers identified in this study yields a novel framework: the Dual-Barricade Model, which classifies obstacles to maternal healthcare utilization into two distinct categories. Structural Barricades include transport difficulties, geographic distance, financial costs, and poor road infrastructure. Socio-Psychological Barricades include husband's disapproval, fear of medical procedures, cultural or religious beliefs, and misinformation regarding clinical interventions.

Critically, the data show that Socio-Psychological Barricades exert a stronger predictive influence on delivery outcomes than Structural Barricades. This finding fundamentally reorients the policy conversation: addressing roads and fees, while necessary, is insufficient. The inner barricade, representing psychological and relational resistance, must be dismantled first, and this requires the tools of community trust rather than clinical instruction.

## Methods

### Study Design

This study employs a Convergent Parallel Mixed-Methods Design. Quantitative and qualitative data were collected concurrently, analyzed independently, and integrated during interpretation. This design ensures methodological triangulation: statistical associations are validated and contextualized by the lived experiences and institutional knowledge of key community actors, producing a more complete and credible evidence base than either approach alone could achieve.

### Study Area

The study was conducted in Epe and Ibeju Lekki LGAs of Lagos State, selected for their

hybrid socio-demographic profile: economically transitioning peri-urban communities with retained traditional governance structures and documented disparities in maternal health outcomes. Both LGAs are served by Primary Health Centres under the Lagos State Primary Health Care Board (LSPHCB) [8].

### Study Population and Sampling

The quantitative sample comprised 500 women of reproductive age (15 to 49 years) who had experienced at least one pregnancy in the preceding 24 months. Sample size was determined using the Cochran formula at a 95% confidence level and 5% margin of error. A multi-stage stratified sampling technique was applied: purposive LGA selection, stratified ward selection, and systematic household sampling within wards.

The qualitative sample was purposively selected to include 25 key informants, comprising traditional rulers, senior religious leaders, PHC facility heads, and community health extension workers (CHEWs), and participants for four Focus Group Discussions (FGDs) composed of male household decision-makers and community women's groups.

### Instrumentation

Quantitative data were collected using the Multidimensional Maternal Health Questionnaire (MMHQ), a structured instrument validated through academic review and pilot-tested in a comparable peri-urban Lagos community. Internal consistency was confirmed at Cronbach's alpha = 0.78. The instrument collected data across five domains: socio-demographic profile, ANC utilization patterns, primary source of trusted health information, perceived barriers to PHC attendance, and male involvement in reproductive health decisions.

Qualitative data were gathered through semi-structured Key Informant Interview (KII) guides and FGD protocols, conducted in both English and Yoruba (Ijebu dialect). All sessions were audio-recorded with informed consent and transcribed verbatim.

### Data Analysis

Quantitative data was analyzed using IBM SPSS Version 28. Descriptive statistics characterize the sample profile. Binary logistic regression identified predictors of early ANC booking and skilled birth attendance, reported as Odds Ratios (OR) with 95% confidence intervals. Chi-square tests evaluated the significance of categorical associations, including the impact of edutainment exposure on male behaviour.

Qualitative transcripts were analyzed through thematic content analysis following Braun and Clarke's six-phase framework [3]. Key emergent themes included Trust Infrastructure, the Garrison Effect (male decision authority), Ancestral Compliance, and the Sovereignty of the Signal.

## Results

### Socio-demographic Profile

Of the 500 respondents, the majority (58.4%; n = 292) were aged 25 to 34 years, representing the peak reproductive window in this population. Most (72.8%; n = 364) were married and co-residing with their husbands, a finding that significantly contextualizes the role of male decision authority documented throughout the study. Secondary school completion was reported by 44.0%, with 31.2% holding post-secondary qualifications. Despite moderate educational attainment, 52.0% of households reported monthly incomes below ₦100,000, highlighting the economic vulnerability that constrains healthcare-seeking autonomy [10].

### The Maternal Care Continuum: From Entry to Dropout

Analysis of care-seeking patterns across the maternal health continuum reveals a progressive decline in service engagement from

ANC initiation through to postnatal care, a pattern consistent with the hypothesis that barriers intensify as the pregnancy advances toward delivery. Comprehensive metrics documenting this attrition pattern across the different sequential stages of the pregnancy cycle are outlined in Table 1.

**Table 1.** Maternal Care Continuum and Service Leakage (N = 500)

| Stage of Maternal Care | n | % | Interpretation |
|---|---|---|---|
| ANC Initiation (≥1 visit) | 412 | 82.4% | High entry into care pathway |
| Optimal ANC Completion (4+ visits) | 314 | 62.8% | Moderate continuity |
| Skilled Birth Attendance | 312 | 62.4% | Significant leakage at delivery |
| Postnatal Care within 48 hours | 148 | 29.6% | Critical drop-off post-delivery |

While ANC initiation is relatively high at 82.4%, a significant service leakage occurs at the point of delivery, where skilled birth attendance drops to 62.4%, as tracked in Table 1. The most alarming dropout is in postnatal care, where only 29.6% of women attended within 48 hours of delivery. Qualitative data contextualize this pattern: women who delivered at home or with Traditional Birth Attendants (TBAs) perceived postnatal care as unnecessary once the immediate danger of delivery had passed, a belief actively reinforced by community norms and, in some cases, by husbands.

## Predictors of Skilled Birth Attendance: The Dominant Role of Social Endorsement

Binary logistic regression identified the primary source of health information as the most statistically powerful predictor of first-trimester ANC booking, surpassing proximity to facility, economic status, and educational level. Detailed odds ratios and statistical confidence limits for each category of primary health communicator are provided in Table 2.

**Table 2.** Logistic Regression-Predictors of First-Trimester ANC Booking by Information Source (N = 500)

| Primary Information Source | OR | 95% CI | p-value |
|---|---|---|---|
| PHC Clinical Staff (Reference) | 1.00 | 1.00[1] | 0.00[1] |
| Traditional Rulers | 3.42 | 2.15 to 5.43 | < 0.001 |
| Religious Leaders | 2.89 | 1.78 to 4.69 | < 0.001 |
| Narrative Media (Edutainment) | 2.14 | 1.34 to 3.42 | 0.002 |
| Community Health Workers | 1.67 | 1.08 to 2.57 | 0.021 |

**p<0.05; p<0.01; ***p<0.001*

As explicitly modeled in Table 2, women receiving health advocacy from Traditional Rulers were 3.42 times more likely to book early for ANC than those relying solely on clinical sources. Faith leader endorsement produced a nearly threefold increase in early booking likelihood. These findings confirm the Trust Infrastructure Theory: the PHC's clinical credibility is substantially amplified when its message is transmitted through culturally authoritative channels. Narrative media (edutainment) also emerged as a significant predictor, demonstrating that even indirect, media-based stakeholder engagement produces measurable improvements in care-seeking behaviour [6, 14].

## Predictors of Skilled Birth Attendance

A separate logistic regression examined predictors of skilled birth attendance at delivery, yielding the statistical indicators displayed in Table 3.

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**Table 3.** Binary Logistic Regression: Predictors of Skilled Birth Attendance (N = 500)

| Variable | OR | 95% CI | p-value |
|---|---|---|---|
| Husband's Approval | 4.42 | 3.21 to 6.08 | < 0.001 |
| Religious Leader Support | 3.15 | 2.45 to 4.02 | < 0.001 |
| Traditional Ruler Endorsement | 3.42 | 2.15 to 5.43 | < 0.001 |
| Edutainment Exposure | 2.14 | 1.34 to 3.42 | 0.002 |
| Proximity to PHC (< 5km) | 1.85 | 1.12 to 2.95 | 0.045 |

As outlined in Table 3, husband's approval was the strongest individual predictor of skilled birth attendance (OR = 4.42; $p < 0.001$), confirming the Garrison Effect: the male partner's attitude toward hospital delivery is more determinative of the delivery outcome than physical proximity to the facility [12, 17, 24]. Traditional ruler endorsement and religious leader support also remained strongly significant, with edutainment exposure producing a meaningful though comparatively modest effect.

## Barriers to Facility-Based Delivery: The Dual-Barricade Model

Respondents were asked to identify factors that had prevented or delayed their utilization of a PHC for delivery. Results were subsequently subjected to factor analysis, which confirmed the two-cluster structure of the Dual-Barricade Model. The primary structural and socio-psychological factors identified by respondents are detailed in Table 4.

**Table 4.** Key Barriers to Facility-Based Delivery as Identified by Respondents (N = 500)

| Barrier | % Endorsing | Description |
|---|---|---|
| Financial Constraints | 68.4% | Inability to afford transport, delivery fees, and medication costs |
| Lack of Transport | 52.2% | Especially acute in riverine and rural settlements |
| Husband's Disapproval | 46.8% | Strongest socio-psychological predictor of home delivery |
| Fear of Medical Procedures | 34.2% | Particularly caesarean sections and injections |
| Negative Health Worker Attitudes | 18.6% | Perceived disrespect and dismissiveness during prior visits |

Financial constraints were the most commonly cited barrier at 68.4%, followed by transport difficulties at 52.2%, as shown in Table 4. However, husband's disapproval, which serves as a Socio-Psychological Barricade, ranked third overall and emerged as the strongest individual predictor of home delivery in logistic regression, demonstrating that the inner barricade exerts a more decisive influence on outcome than the structural one. Fear of medical procedures at 34.2% and negative health worker attitudes at 18.6% further confirm that the relationship between the community and the health system carries unresolved tensions that structural investments alone cannot address [2, 22].

## Impact of Multi-stakeholder Interventions on Health Outcomes

Communities and households exposed to coordinated MSHPI (combining edutainment, traditional ruler decrees, religious leader messaging, and PHC outreach) demonstrated significant improvements across all measured

maternal health indicators. The proportions of distinct behavioural and awareness advancements captured post-implementation are shown in Table 5.

**Table 5.** Observed Improvements Following Multi-stakeholder Intervention (N = 500)

| Outcome Indicator | n | % | Note |
|---|---|---|---|
| Increased Facility-Based Deliveries | 342 | 68.4% | Most impactful outcome |
| Improved Community ANC Awareness | 311 | 62.2% | Driven by edutainment |
| Increased ANC Attendance (4+ visits) | 288 | 57.6% | Gatekeeper endorsement key |
| Improved Male Involvement | 194 | 38.8% | Post-edutainment series |
| Perceived Reduction in Mortality | 122 | 24.4% | Community self-report |

The most pronounced outcome collected in Table 5 was the increase in facility-based deliveries (68.4% of respondents in intervention-exposed communities), driven primarily by male behaviour change following edutainment exposure. Chi-square analysis confirmed that the association between the 'Man of the House' edutainment series and male supportive behaviour, including transport provision and financial planning for hospital delivery, was statistically significant ($p = 0.004$). The 57.6% increase in ANC attendance was most strongly linked to traditional ruler endorsement, while improved community awareness at 62.2% reflected the synergistic effect of layered communication across stakeholder channels [4, 16].

## Qualitative Thematic Findings

**Theme 1:** The Sovereignty of the Signal Key Informant Interviews with traditional rulers, religious leaders, and PHC administrators consistently surfaced the theme of messenger credibility as the primary determinant of message adoption. Respondents described a hierarchy of trusted voices in which the clinical health worker ranked lower than the King, the Imam, or the Pastor. One PHC facility head in Ibeju Lekki noted that attendance at ANC registration events rose sharply following a formal decree by the community's traditional ruler, without any change in the services offered or the facility's physical accessibility. This pattern was termed the 'Sovereignty of the Signal', representing the point at which a health message is accepted as authoritative because of who delivered it, not what it contained.

**Theme 2:** The Garrison Effect Focus Group Discussions with male community members revealed that men did not perceive themselves as barriers to maternal care; rather, they understood themselves as protectors exercising informed caution. Several participants expressed concern about the perceived impersonal or disrespectful treatment their wives might receive at public health facilities, which had informed their preference for TBA-assisted home births. Critically, the 'Man of the House' edutainment series, which framed hospital delivery as an act of responsible fatherhood, was cited by multiple participants as having changed their perspective. This finding validates the proposition that male behaviour change requires narrative reframing, not clinical argumentation.[4,12]

**Theme 3:** Structural Fragmentation as a Systems Failure Traditional rulers and religious leaders across both LGAs independently described the same structural problem: they are rarely consulted by health authorities before health campaigns are launched. PHC managers similarly reported receiving no institutional framework for community engagement. The result is that health messaging from official channels competes with, rather than aligns with, messages from community authority structures, creating confusion and reducing uptake. This theme directly validates the Dual-Barricade Model's emphasis on systemic

fragmentation as a contributor to socio-psychological barriers.

## Discussion

The findings of this study make a compelling empirical case for a fundamental re-conceptualization of maternal health promotion in peri-urban Nigeria. The dominant paradigm, which measures success by the construction of facilities, the training of clinical staff, and the distribution of health education materials, is necessary but demonstrably insufficient in communities where social legitimacy is the primary currency of health-seeking behaviour [7].

The Trust Infrastructure Theory developed in this study provides a conceptual bridge between public health science and community sociology. The data demonstrates that clinical credibility is not intrinsic to the PHC; it is relational. It must be cultivated through deliberate engagement with the authority systems that communities have already invested with their trust. When traditional rulers endorse the PHC, they are not simply repeating a health message; they are lending their social capital to the health system, enabling it to operate within the community's existing trust economy [5].

The Dual-Barricade Model similarly advances the field by demonstrating that infrastructural improvements, while important, have limited effect on maternal mortality when the inner, socio-psychological barricade remains intact. A paved road to a PHC is irrelevant if a woman lacks her husband's permission to travel it. This finding has profound implications for resource allocation in Nigerian public health: it suggests that investments in community engagement and narrative communication should be treated as essential infrastructure, not as supplementary activities [6, 14].

The magnitude of the Garrison Effect, demonstrated by the OR of 4.42 for husband's approval as a predictor of skilled birth attendance, underscores a gap that the field has long identified but rarely addressed with structural solutions. Edutainment represents a cost-effective, culturally congruent approach to closing this gap. The 68.4% improvement in facility-based deliveries among edutainment-exposed communities is not a marginal gain; it is a transformative one, achieved not through clinical investment but through storytelling [4, 17, 24].

The postnatal care dropout rate at 29.6% remains the most critical unresolved challenge identified in this study. While the MSHPI improved ANC attendance and facility delivery rates substantially, it did not produce a proportionate improvement in postnatal engagement. This suggests that the Trust Infrastructure required for postnatal care engagement requires a distinct, targeted intervention, one that addresses the community belief that medical care ends at delivery [1, 20].

## Conclusion

This doctoral study establishes that maternal and infant survival in Lagos State is a function not of clinical investment alone, but of Integrated Advocacy: a coordinated alignment of medical expertise, traditional authority, religious legitimacy, and male household engagement that creates the social conditions for health-seeking behaviour to flourish. The Trust Infrastructure Theory and Dual-Barricade Model introduced in this study contribute original frameworks to the public health literature, providing both diagnostic tools for understanding community health barriers and prescriptive tools for designing interventions that can overcome them. The Community Health Advocacy Council (CHAC) model proposed in this study offers a scalable, institutionalizable mechanism for embedding multi-stakeholder collaboration into the routine architecture of PHC governance in Nigeria. Maternal mortality in Nigeria is not an unsolvable problem. It is a coordination problem, one that can be addressed when the

clinic, the throne, the pulpit, and the household operate not as separate systems delivering competing messages, but as a unified advocacy architecture, each amplifying the other's signal in the interest of every expectant mother's survival.

## Recommendations

### For the Lagos State Government and Ministry of Health

Institutionalize Community Health Advocacy Councils (CHACs) in every rural and peri-urban LGA, mandating quarterly coordination between PHC administrators, traditional rulers, and clergy as a formal component of PHC governance.

Adopt and scale the narrative media model, specifically the 'Man of the House' approach, as the official framework for male engagement in maternal and reproductive health campaigns across Lagos State.

Commission a state-wide Trust Infrastructure Assessment to map the social authority structures in each LGA and identify the most credible channels for maternal health communication.

### For Traditional and Religious Institutions

Integrate maternal health reporting as a standing agenda item in traditional ward meetings, making ANC registration and facility delivery a matter of community responsibility endorsed by royal authority.

Designate monthly 'Safe Motherhood' sessions in religious gatherings, utilizing the authority of the pulpit to dismantle misinformation regarding immunizations, caesarean sections, and hospital births.

### For Further Research

Longitudinal studies should evaluate the sustained impact of CHACs on maternal mortality rates over a 3-to-5-year period.

Future research should investigate the role of digital platforms, including WhatsApp-based edutainment and community radio, in extending the reach of multi-stakeholder messaging in areas where in-person engagement is constrained by geography.

A comparative study across southern Nigerian states would assess the transferability of the Trust Infrastructure framework beyond Lagos.

## Ethical Approval

Ethical approval for this study was formally obtained from the Lagos State Health Research Ethics Committee under Reference Number LSHSC/HREC/24/04/53. Written and verbal informed consent were acquired from all participating respondents prior to engagement, with absolute anonymity and data confidentiality guaranteed throughout the research cycle.

## Data Availability

The datasets generated and analyzed during the study are not publicly available due to participant privacy protections and institutional ethical constraints. De-identified datasets may be made available by the corresponding author upon qualified request for verified academic research purposes, subject to appropriate institutional ethical clearance.

## Author Contributions

The sole author (B.E.O.) designed the study architecture, developed the Multidimensional Maternal Health Questionnaire (MMHQ), coordinated the field research teams during concurrent quantitative and qualitative data collection, executed the quantitative statistical analyses (including binary logistic regression and Chi-square tests) in SPSS, performed qualitative thematic content modeling, and compiled the complete original manuscript and its subsequent revisions.

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## Conflict of Interest

The author declares no conflict of interest.

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# Barriers to Early Detection of Chronic Diseases among University Students in Nigeria: Evidence from a Cross-Sectional Survey

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***Abstract*** *Chronic diseases are more than ever affecting young adults in developing countries and countries in the middle and low-income regions. Although early screening is vital for detecting such diseases, the participation rate among Nigerian university students in this screening is low. This study aimed to identify challenges in the early detection of chronic diseases among tertiary school students. A cross-sectional survey was conducted among 500 undergraduate students at a college in Nigeria. Data collection utilised structured, self-administered questionnaires that collected information on socio-demographic characteristics, awareness of conditions, risk perception, and barriers to screening. The analysis used descriptive statistics and chi-square tests at the 5% significance level. Of those who answered: 88.6% known about chronic diseases; only 40.2% understood enough; only 35.8% believed they were at risk. Key barriers included low susceptibility perception (64%), financial constraint (58.4%), fear of being diagnosed (55.2%), lack of screening services provided (52.6%), and lack of awareness of these services (49.8%). Institutional barriers, including long waiting time (46.2%) and limited on-campus health service (44%), were also observed. While many university students are aware of various chronic diseases, perceptions of risk with several structural issues are insufficient to allow for early detection. Enhancements of health education initiatives, improved availability of screening services, and supportive policy measures are all urgent issues. Chronic diseases, early detection, screening barriers, university students, Nigeria.*

***Keywords*** *Chronic Diseases, Early Detection, Nigeria, Screening Barriers, University Students.*

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## Introduction

Chronic diseases (also called non-communicable diseases (NCDs) such as hypertension, diabetes mellitus, and cardiovascular disease, represent serious public health challenges worldwide. Their occurrence is increasing quite significantly in places like Nigeria, a low- and middle-income nation (World Health Organisation [1]. Traditionally linked to an older demographic, lifestyle shifts and urbanisation have led to an increase in incidence among the young. Early diagnosis through adequate screening is vital for curbing sequelae, improving quality of life, and lowering healthcare expenditure.

Although the literature exists to scrutinise the burden of chronic diseases in university students in Nigeria and other developing countries, the main trend in publications is to estimate prevalence or determine risk factors without examining the root causes of poor engagement in early detection [2]. Therefore, leaves some crucial questions (gaps) unresolved about why uptake remains significantly low despite the growing vulnerability of these populations. Also, the current research generally focuses on clinical indicators of medical conditions (e.g., blood pressure, BMI and glucose levels) and ignores broader institutional, socio-cultural, and psychological factors that affect health-seeking behaviour. Research on youth health behaviour does not consider the challenges posed by inadequate campus facilities and the inability to provide adequate screenings due to the absence of targeted preventive interventions [2].

The uptake is particularly low among young adults, such as university students, who may view themselves as healthy or at limited risk [3]. Different interlocking barriers, such as individual beliefs, institutional limitations, socio-cultural influences, and broader systemic issues like delayed diagnosis and treatment, markedly compound long-term disease burdens. This study was conducted in this regard, as this demographic group is understudied for its contribution to preventive care strategies in Nigeria. It sheds light on the challenges university students face in accessing early screenings for chronic disease. Poor knowledge and awareness. Inadequate knowledge of chronic conditions and risk factors is also a significant barrier to screening among university students in Nigeria. Most of the college students are less aware of conditions like hypertension and diabetes, but with the knowledge of symptoms and early signs, the importance of screening is low. Not getting help in terms of preventive services [3, 4]. Many of the learners in tertiary-level institutions do not have well-endowed income, and are receiving low allowances on a regular basis, which makes getting medical tests and travelling to healthcare for cancer screening in an environment like Nigeria a heavy burden. It is widely reported that financial constraints are among the main reasons for poor preventive health practices among university students in Nigeria. Many Nigerian universities have health centres that handle minor problems rather than comprehensive preventive medical treatment. In the absence of on-campus screening for diseases and diagnostic technologies, students are unable to detect chronic illnesses early [5]. Some Nigerians understand chronic disease as spiritual or genetic diseases that cannot be escaped. These perceptions result in the devaluation of screening services, thereby demotivating their utilisation [6].

This study addresses a critical gap in the existing literature by examining the multi-level barriers influencing the early detection of chronic diseases among university students in Nigeria, with a significant focus on the individual -level and structural determinants

## Materials and Methods

### Study Design

The study employed a descriptive cross-sectional analytical design to explore barriers influencing early chronic disease detection

among young adults in Nigerian tertiary institutions. This design entails collecting data from a defined population at a single point in time

**Study Area and Population**

The research targeted undergraduate students at Ambrose Alli University, Edo State, Nigeria, with a total enrolment of 27,388 [7].

**Sample Size Determination**

Utilising Yamane's formula [8] for finite populations:

**Sample Size Calculation**

$n = N / [1 + N(e^2)]$
*Where:*
$n$ = *required sample size*
$N$ = *total population (27,388 students)*
$e$ = *margin of error (0.05 at 95% confidence level)*
*Substituting the values:*
$n = 27,388 / [1 + 27,388(0.05^2)]$

A minimum sample size of 394 was calculated for a population of 27,388, with a 5% margin of error. Ultimately, data from 500 students were collected, accounting for potential non-responses.

**Sampling Technique**

A multistage sampling approach was used to recruit participants from AAUs in three key states, and the study was conducted over 1 week. In the first stage, faculty members were selected at random from across different disciplines. In the second stage, a random department section was performed between the selected faculties. Moreover, in stage three, participant selection was conducted using systematic protocols based on an eligibility criterion, ensuring that diverse academic backgrounds were accurately represented. Through this approach, the risks of sampling bias were reduced, and a comprehensive representation of the sample from diverse academic contexts was promoted.

The reliability test of the two perceived-susceptibility items (probably the reversed-scored susceptibility item and the worry about consequences item) yielded a negative Cronbach's alpha of -0.113, based on only two items. A negative alpha indicates very low consistency of responses across the scale, unacceptable internal consistency, and does not meet the basic assumptions of the Cronbach alpha reliability model [9].

**Data Collection Instrument**

A structured self-administered questionnaire was developed, encompassing demographic characteristics, awareness regarding chronic diseases, risk perception and screening barriers

**Data Analysis**

Data analysis was performed using SPSS version 25 [10], in which descriptive statistics, including frequencies and percentages, were computed, along with chi-square analyses to identify statistically significant associations ($p < 0.05$). Independent predictors of chronic disease screening propensity were evaluated, and descriptive multivariate logistic regression and bivariate statistics were performed. Variables whose p-value $< 0.20$ were determined through bivariate analyses and were included in the regression model. AORs and 95% confidence intervals (CIs) were evaluated, and the significance level was determined to be $p < 0.05$.

## Results

### Socio-demographic Variables

A total of 500 students participated, as shown in Table 1, with a mean age recorded at 24.75 years; females comprised the majority at 51.8%, predominantly enrolled in their second or third year.

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**Table 1.** Gender of Participants

| Category | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Male | 241 | 48.2 | 48.2 | 48.2 |
| Female | 259 | 51.8 | 51.8 | 100.0 |
| **Total** | **500** | **100.0** | **100.0** | |

In a broader sense, the gender distribution in the sample appears fairly balanced: 48.2% (n = 241) of participants were male, while 51.8% (n = 259) were female (Table 1).

**Table 2.** Age of Participants

| Age | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| 16.00 | 7 | 1.4 | 1.4 | 1.4 |
| 17.00 | 16 | 3.2 | 3.2 | 4.6 |
| 18.00 | 20 | 4.0 | 4.0 | 8.6 |
| 19.00 | 31 | 6.2 | 6.2 | 14.8 |
| 20.00 | 31 | 6.2 | 6.2 | 21.0 |
| 21.00 | 36 | 7.2 | 7.2 | 28.2 |
| 22.00 | 39 | 7.8 | 7.8 | 36.0 |
| 23.00 | 35 | 7.0 | 7.0 | 43.0 |
| 24.00 | 23 | 4.6 | 4.6 | 47.6 |
| 25.00 | 32 | 6.4 | 6.4 | 54.0 |
| 26.00 | 41 | 8.2 | 8.2 | 62.2 |
| 27.00 | 30 | 6.0 | 6.0 | 68.2 |
| 28.00 | 33 | 6.6 | 6.6 | 74.8 |
| 29.00 | 26 | 5.2 | 5.2 | 80.0 |
| 30.00 | 33 | 6.6 | 6.6 | 86.6 |
| 31.00 | 38 | 7.6 | 7.6 | 94.2 |
| 32.00 | 29 | 5.8 | 5.8 | 100.0 |
| **Total** | **500** | **100.0** | **100.0** | |

Next, among the participants' sociodemographic characteristics, age is a key factor. At a glance, participants' ages range from 16 to 32 years. Table 2 shows that the total sample (N) is 500 respondents, and the valid percentages are equal across all categories, implying that there are no missing age values in the dataset (all 500 responses are valid). The age profile suggests that the sample is overall young, as the chart is concentrated in the early to late 20s. However, the distribution is fairly even across all ages, with a mild peak in the mid-20s. From the frequencies in Table 2, the mean age is approximately 24.75 years, and the median age is 25 years (since the middle respondent is 25). The most common age, i.e., mode, is 25 years. The table also reveals that age typically varies by about ~4.5 years from the mean, meaning that its standard deviation is approximately 4.48. The overall distribution is approximately symmetric, i.e., it is not strongly skewed towards older or younger ages. So, while respondents are spread across ages, the mid-20s, especially 22–26, is the strongest cluster.

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## Awareness and Knowledge

While most respondents (88.6%) reported being informed about chronic diseases, only 40.2% demonstrated strong knowledge concerning associated risk factors or prevention methods.

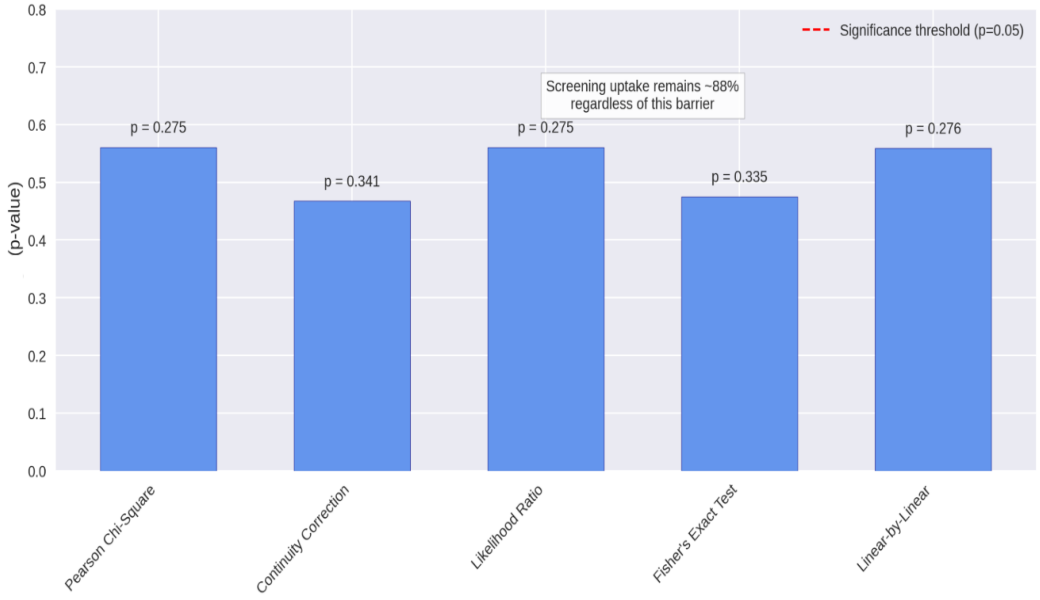


**Figure 1.** Chi-Square Results Barrier 1 - Lack of information

The chi-square test in Figure 1 shows that there is no statistically significant correlation ($\chi^2 = 1.189$, df = 1, p = 0.275). Other supporting statistics are the likelihood ratio (1.189, p = 0.275), Fisher's Exact Test (p = 0.335 two-sided), and continuity correction (p = 0.341), which are all in line with non-significance (Maria et al., 2024). Zero cells were expected to have fewer than 5 (i.e., at least 29.04), which met chi-square criteria and provided strong inference [11, 12, 20].

These findings directly impact the research objective (the assessment of individual, societal, and institutional barriers) and the research question (the identification of barriers to early detection). This non-association puts the perception of a lack of need as the major discouraging factor to the test and cements the idea that the institutional setting is dominant over the individual-level natural barriers in college settings.

## Risk Perception

Only about one-third (35.8%) believed they were susceptible to developing chronic conditions; many tended to associate these illnesses primarily with older demographics.

**Table 3.** Barrier - Need Screening (Fear of Results or Stigma)

| Fear of results/stigma | Statistic | .00 | 1.00 | Total |
|---|---|---|---|---|
| No | Count | 34 | 237 | 271 |
| | % within Fear of results/stigma | 12.5% | 87.5% | 100.0% |
| | % within screened_any | 56.7% | 53.9% | 54.2% |
| Yes | Count | 26 | 203 | 229 |
| | % within Fear of results/stigma | 11.4% | 88.6% | 100.0% |
| | % within screened_any | 43.3% | 46.1% | 45.8% |
| Total | Count | 60 | 440 | 500 |
| | % within Fear of results/stigma | 12.0% | 88.0% | 100.0% |
| | % within screened_any | 100.0% | 100.0% | 100.0% |

The chi-square and cross-tabulation of the barrier "***Fear of results/stigma***" in Table 3 show a trend similar to that found at the individual level in this sample of 500 undergraduates. Among the 271 people who did not state fear of results or stigma as a deterrent (54.2%), 87.5% (n=237) had been screened, and 12.5% (n=34) had not. The reason is that, out of the 229 respondents (45.8) who actually affirmed this fear of a positive diagnosis or social stigma, screening uptake was also almost the same at 88.6% (n=203), with 11.4% (n=26) never screening at all.

The perception of screening was also extremely positive (88 per cent, 440/500), and the barrier itself was supported by a significant minority (45.8 per cent), indicating that the fear of the diagnosis outcome or stigmatisation is of moderate prevalence in this group of young adults. Surprisingly, even acknowledging fear contributed equally to screening as not acknowledging it, with an insignificant 1.1 percentage-point difference.

## Logistic Regression

**Table 4.** Logistics Regression Results

| Variables | B | S.E. | Wald | df | Sig. | Exp(B) | 95% C.I. Lower | 95% C.I. Upper |
|---|---|---|---|---|---|---|---|---|
| Knowledge level (poor/fair/good) | -.279 | .269 | 1.077 | 1 | .299 | .757 | .447 | 1.281 |
| Perceived susceptibility (reversed) | .073 | .101 | .528 | 1 | .468 | 1.076 | .883 | 1.310 |
| I would be worried about the consequences if I were found to have a chronic disease. | .063 | .097 | .418 | 1 | .518 | 1.065 | .880 | 1.288 |
| Age of Respondents | -.010 | .032 | .104 | 1 | .747 | .990 | .930 | 1.054 |
| Sex | -.365 | .283 | 1.658 | 1 | .198 | .695 | .399 | 1.210 |
| Year of Study | -.085 | .126 | .455 | 1 | .500 | .918 | .717 | 1.176 |
| Residence | -.216 | .167 | 1.666 | 1 | .197 | .806 | .581 | 1.118 |
| Constant | 3.551 | 1.168 | 9.243 | 1 | .002 | 34.850 | | |

The regression analysis was applied to evaluate the relationship and impact of selected factors on the dependent variable shown in Table 4. Logistic regression estimates the magnitude of the relationship with Beta values, the explanatory power with R Square, and the significance of variables with t-statistics [13, 14]. The binary logistic regression (Step 1) model used was evaluated on predictors of screening uptake (dependent variable: ever screened vs never screened) in 500 undergraduate students with the inclusion of knowledge level, perceived susceptibility (reversed), perceived severity/worry, age, gender (sex), year of study, and residence. The model had low overall explanatory power ($R2 = 0.023$) and accounted for only a small proportion of the variance [14]. The constant was highly significant ($p = 0.002$), indicating a high probability of screening as a base. However, none of the predictors entered into the model achieved statistical significance (all are $p > 0.05$), indicating that none has an independent effect on screening uptake when adjusting for the others.

## Discussion

This study indicates that although there was widespread awareness of chronic diseases among the university population, knowledge of risk perception was significantly reduced, corroborating other studies showing that mere

awareness is not enough to influence preventive health behaviours [4]. Low levels of perceived susceptibility emerged as the most significant barrier to increased risk, consistent with the Health Belief Model, which indicates that individuals may be less likely to comply with preventive behaviours unless they see them as personally helpful [15]. Sadly, the perception of chronic illness is mainly viewed through the perspective of age, with this group being less willing to do proactive screening to prevent these diseases. Financial constraints and access issues, as highlighted by a review of screening resources available in Nigeria, underscore systemic failures in the country's health care system. Beyond these barriers, anxiety related to screenings should also be addressed, and some psychological support devices should be designed to alleviate these fears. In the upcoming months, such interventions targeting uptake of the screening approach are planned to contribute to increased overall public health outcomes for this group and to help effectively address the barriers we identified earlier to timely identification, thereby improving overall management practices. Additional regression analyses suggest that some important predictors influencing these screening behaviours are observed in the sample. We identified perceived risk as the main predictor, thereby suggesting its importance in preventive health behaviour, as predicted by the Health Belief Model [15]. Initiatives to increase perceived susceptibility towards screening behaviours by university students may have a substantial impact on screening participation. Knowledge was also a significant predictor, and targeted health education campaigns may be helpful. Conversely, a lack of financial resources was shown to greatly limit engagement in screening activities, reflecting long-standing systemic barriers within health systems. The lack of resources and policy disparities reflect outcomes observed at other Nigerian tertiary facilities, where campus clinics are equipped with outdated devices and have inadequate staffing [16, 17].

The findings have also highlighted that fear of diagnosis, cultural beliefs and stigma play their role as cultural barriers that prevent students from seeking early detection services for their mental health issues. However, it is recommended that interventions be based on culturally sensitive approaches to prevent misconceptions and negative perceptions surrounding chronic diseases. The universities are required to adopt stigma-reduction approaches to normalise the health screening process among students and promote a positive attitude towards preventive care to the desired extent. This can be achieved through culturally appropriate messages, storytelling, and testimonials that closely resonate with the student's values and beliefs [18, 19].

## Conclusion

Although a high level of awareness surrounding early detection methods targeting chronic health problems has improved among Nigerian undergraduate youth, limited perception of risk, as well as financial limitations and limited accessibility routes prevent a strong diagnostic capability that is critical, greatly hindering both immediate medical delivery, whilst adding further burden of long-term, re-harm to unaddressed condition in-and-out addressing on the issue that this direct approach to the problem will bring to them and focus on the health promotion aspect leading towards healthy living and the avoidance or prevention of future episodes that could cause even more direct repercussions of untreated medical problems directly leading to them in the future!

## Recommendations

1. Universities must establish complementary or subsidised regular screening programs in their institutions. Health education efforts should not only concentrate on individual

risk assessment, but also change students' views on various conditions.

2. In parallel with allocating resources, campus health centres should also be improved to allow access pathways to services—this would better support their services. A system in which essential screening services are readily accessible on-site.
3. Policymaking should focus on developing policies and procedures that promote the implementation of preventive healthcare programs explicitly targeted for tertiary educational settings and that support students in taking an active role, identifying relevant prevention practices, and engaging in preventing the risks associated with health problems.
4. Further research is required on the methods of interventions that increase the rates of participation, closely linked to previously established contexts shaping underlying motivations driving behavioural changes, fostering healthier communities evolving continuously, adapting to meet emerging needs adequately, responding proactively whenever possible!

## Ethical Approval

Ethical approval was obtained from the Ambrose Alli University Research Review Board. Participation was voluntary, and informed consent was obtained. Confidentiality and anonymity were strictly maintained.

## Author Contributions

Taiwo Akhigbe conceived the presented idea, planned and carried out the data collection, analysed the data, and drafted the manuscript. Osede Ignis Iribhogbe, review the titles and supervise the manuscript development.

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## Conflict of Interest

The authors declare that there is no conflict of interest.

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## Data Availability

The data for this study are available on direct request from the authors.

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# Assessment of Knowledge, Attitude and Practice toward Medical Waste Management among Healthcare Workers in Wau, Western Bahr El Ghazal State, South Sudan: Evidence for Action

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***Abstract*** *Medical waste contains potentially harmful materials is a public health problem worldwide. This study describes knowledge, attitudes, and practices towards medical waste management among healthcare workers from selected healthcare facilities in Wau. A cross-sectional, descriptive, and mixed-approach study was conducted among 135 healthcare workers randomly selected from 14 healthcare facilities. A pre-tested, structured questionnaire, key informant interviews, and observation checklist were used to collect the intended data. Descriptive and thematic analyses were performed. Findings were presented using tables, graphs, pie charts, and quotes.Of 135 respondents, 55% (n=74) were females and 45% (n=61) were males. The majority, 91% (n=123), had good knowledge about medical waste management. Healthcare workers at primary healthcare and government facilities had slightly better knowledge compared to those at hospitals or private facilities. 74% (n=100) had a positive attitude and perceived medical waste management as a priority. Regarding practices 47% were unvaccinated against work-related illnesses, used gloves (58.5%) and overalls (24.4%) as personal protective equipment. Healthcare workers were found having good knowledge, positive attitudes, and fair practices. Thus, continuous training on medical waste management, awareness, vaccination, provision of adequate personal protective equipment, and supply of waste management facilities are required to improve the health and wellbeing of both patients and healthcare workers.*

***Keywords*** *Awareness, Healthcare Workers, Medical Waste Management, South Sudan.*

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## Introduction

The concerns over medical waste management have increased in recent years globally due to improper disposal. This poses a public health risk coupled with the lack of knowledge and inappropriate attitude and practices among healthcare workers and the public at large.

Waste management is a conduit at the crossroads of inputs from producers, users, and outputs to environmental compartments, with the overall goal to clear the residues and reutilize cleared materials and natural resources [1, 15].

WHO and UNICEF, through the Joint Monitoring Programme, have placed three indicators to measure waste management at healthcare facilities. A basic waste management level is at least acceptable [2, 17]. At this level, waste is safely segregated into three bins, and sharps and infectious waste are treated and disposed of safely. The second lower level is a limited separation and/or treatment and disposal of sharps and infectious waste, but not all requirements for basic service are met. However, where there is no service, there are no separate bins for sharps or infectious waste, and sharps and/or infectious waste are not treated/disposed of safely [3].

In South Sudan, although a national action plan (2012 – 2016) was developed, there is no evidence of its implementation at the facility level. With support from the government of Canada through the World Health Organization (WHO), South Sudan has installed the first-ever medical waste management unit at Juba Teaching Hospital in 2023. The mounted facility is a temperature-controlled incinerator that is used to collect, transport, and treat infectious waste and sharps [4, 20].

So far, the majority of healthcare facilities in low-income countries, including South Sudan, don't adhere to medical waste management minimum standards. In addition, the current methods for treatment and disposal are dissatisfactory, and healthcare workers, both technical and non-technical, still face many serious risks to their health and safety. Therefore, the risk associated with medical waste management is high to very high, and public awareness on medical waste issues among the population is low [5]. This study aimed at assessing the knowledge, attitude, and practice toward medical waste management among healthcare workers drawn from fourteen (14) healthcare facilities operating in Wau Municipality, South Sudan.

## Materials and Methods

### Study Design and Study Area

A cross-sectional, descriptive, and mixed-approach (quantitative & qualitative) study was conducted from February to May 2026 among healthcare workers in Wau Municipality, Western Bahr el Ghazal State, South Sudan [6]. The state has a population of 127,384 people located at the eastern banks of the Jur River. The place is a home to several communities that mostly practice farming, livestock keeping, or working with government, private, or business sectors.

### Study Population

The study targeted healthcare workers, which included doctors, physicians, nurses, midwives, public health officers, pharmacists, lab technicians, waste collectors, and cleaners who are directly involved in medical waste management at the health facility level. The inclusion criteria included all who are 18 years and above, mentally sound, working at a healthcare facility, accepted to participate, and provided written informed consent. While exclusion criteria included those who were less than 18 years old or declined to consent or were not healthcare workers. The participants were interviewed face-to-face by trained research assistants at their respective healthcare facilities.

### Sample Size and Sampling

According to a previous study [7], the study sampled all 14 healthcare facilities operating in Wau Municipality according to the list provided by the Ministry of Health in Western Bahr el Ghazal State.

The list included three (3) hospitals, four (4) primary healthcare centers (PHCCs), four (4) primary healthcare units (PHCUs), and three (3) clinics.

The allocation of healthcare workers was done proportionally per healthcare facility as shown in Table 1, whereby 135 healthcare workers were selected using systematic random sampling. Every 3rd healthcare worker was selected randomly from the list of healthcare workers received. In addition, 14 health facilities in charge were selected for qualitative data collection.

### Data Collection

The study used a structured and pretested questionnaire to assess the knowledge, attitude, and practices of the respondents. The questionnaire was comprised of socio-demographic characteristics, knowledge, attitude, and practice-related questions, both open-ended and closed-ended.

The overall knowledge of the respondents was calculated from five major questions: “Are you aware of what medical waste is?" “If yes, are you trained on medical waste management?”, “Do you know the standards and regulations on medical waste management? And do you know that medical waste should be segregated?” The response to each of the questions was scored as either correct (2) or incorrect (0). The total sum of the scores was (2x5 = 10). The overall knowledge was finally categorized as: any respondent who scored 5 and above was considered to have good knowledge, and any respondent who scored below 5 was considered to have poor knowledge. For attitude and practices, any respondents who provide the most favorable responses are considered to have positive attitudes or good practices.

In addition, a key informant checklist was used to collect qualitative data from healthcare facilities in charge through face-to-face interviews and sound recording using a smartphone.

The questionnaire and key informant interview checklist were designed in English and translated verbally into the Arabic language, which is a common language spoken in the area, to those who don’t understand or write in English. Data collection was done by well-trained research assistants that were bilingual in English and Arabic.

### Data Management and Statistical Analysis

The collected data was cleaned and double-checked for consistency and completeness. After data entry, descriptive analyses were performed using IBM SPSS software (version 26). The analyses, such as frequencies, percentages, and chi-square tests, were used to examine the relationship between categorical variables, including age, sex, education, and awareness of medical waste management. The results were presented using tables, pie charts, and graphs.

Qualitative data was analyzed using NVivo software. After recording data, transcripts and major themes were extracted and summarized.

## Results

### Socio-demographic Characteristics

A total of 135 healthcare workers (55% females, 45% males) were interviewed. The majority, 67% (n=90), of the respondents were aged 20-30 years old, followed by 27% (n=36) who were aged 31-40 years old. The education background showed a majority, 60% (n=81), attended university, 24% (n=33) were uneducated, and 12% of respondents completed secondary school. Meanwhile, the majority, 19% (n=25), of respondents were from Mary Help Hospital; 15% (n=20) were from Wau

Teaching Hospital; and 7% (n=10) were from Comboni Hospital, while others were drawn from four primary healthcare centers (PHCCs), four primary healthcare units (PHCUs), and three private clinics (Table 1).

**Table 1.** Socio-demographic Characteristics of Respondents, Wau (n=135)

| Characteristics | Variable | Frequency | % |
|---|---|---|---|
| Sex | Male | 61 | 45 |
| | Female | 74 | 55 |
| | **Total** | **135** | **100** |
| Age | 20-30 years | 90 | 67 |
| | 31-40 years | 36 | 27 |
| | 41-50 years | 7 | 5 |
| | 51 years and above | 2 | 1 |
| | **Total** | **135** | **100** |
| Education | None | 33 | 24 |
| | Primary | 5 | 4 |
| | Secondary | 16 | 12 |
| | University | 81 | 60 |
| | **Total** | **135** | **100** |
| Health facility | Wau Teaching Hospital | 20 | 15 |
| | Comboni Hospital | 10 | 7 |
| | Mary Help Hospital | 25 | 19 |
| | Hai Dinka PHCC | 10 | 7 |
| | Lokoloko PHCC | 10 | 7 |
| | Muktah PHCC | 10 | 7 |
| | Sikka Hadid PHCC | 10 | 7 |
| | Aljazera PHCU | 10 | 7 |
| | Bazia PHCU | 5 | 4 |
| | Hai Bafra PHCU | 5 | 4 |
| | Jebel Khir PHCU | 5 | 4 |
| | Clinic I | 5 | 4 |
| | Clinic II | 5 | 4 |
| | Clinic III | 5 | 4 |
| | **Total** | **135** | **100** |

## Knowledge of Healthcare Workers towards Medical Waste Management

In table 2, most of the respondents, 96.3% (n=130), were aware of medical waste management. The majority (76.3%, n=103) of respondents were trained on medical waste management, and 52.6% (n=71) attended specialized training on medical waste management. Less than half, 43.7% (n=59), preferred awareness rising, and only 37% (n=50) of respondents chose on-the-job training. 75.6% (n=102) of respondents knew about medical waste management standards and regulations. Moreover, 88.9% (n = 120) of respondents were knowledgeable about infectious waste segregation according to color-coded bins, e.g., yellow, red, and blue. Generally, most 91% (n=123) of the respondents had good overall knowledge about

medical waste management compared to 9% (n=12) of respondents that had poor knowledge about medical waste management (Table 2).

**Table 2.** Knowledge of Respondents towards Medical Waste Management, Wau (n=135)

| Knowledge | Variable | Frequency | % |
|---|---|---|---|
| Awareness of medical waste management (MWM) | Yes | 130 | 96.3 |
| | No | 5 | 3.7 |
| | **Total** | **135** | **100** |
| Training on medical waste management | Yes | 103 | 76.3 |
| | No | 32 | 23.7 |
| | **Total** | **135** | **100** |
| MWM specialized training conducted during the last 2 years | Yes | 71 | 52.6 |
| | No | 64 | 47.4 |
| | **Total** | **135** | **100** |
| Mode of training preferred | on job training | 50 | 37.0 |
| | awareness | 59 | 43.7 |
| | programmes/posters | 24 | 17.8 |
| | others | 2 | 1.5 |
| | **Total** | **135** | **100** |
| Knowledge of MWM standard and regulations | Yes | 102 | 75.6 |
| | No | 33 | 24.4 |
| | **Total** | **135** | **100** |
| Knowledge of medical waste should be segregated? | Yes | 120 | 88.9 |
| | No | 15 | 11.1 |
| | **Total** | **135** | **100** |
| Do you know about color coding? | Yes | 109 | 80.7 |
| | No | 26 | 19.3 |
| | **Total** | **135** | **100** |
| If yes, what are the color- coded bins do you have at this facility? | Yellow | 54 | 46.2 |
| | Red | 45 | 38.5 |
| | Blue | 18 | 15.3 |
| | ***Total** | **117** | **86.7** |
| Overall knowledge | Good | 123 | 91 |
| | Poor | 12 | 9 |
| | **Total** | **135** | **100** |

## Attitude of Healthcare Workers towards Medical Waste Management

A majority, 43.7% (n=59), of respondents report injury while handling medical waste, while 38.5% (n=52) of respondents wash the injury sites after getting exposed to a medical waste injury. On the other hand, nearly three quarters of respondents, 74% (n=100), perceived waste management as a priority, and only 23% (n=31) of respondents perceived waste management as important for environmental safety. 60.8% (n=82) of respondents were satisfied with the way technical healthcare staff safely handle medical waste. However, 40% (n=54) of respondents

were unsatisfied with non-technical healthcare staff's safe handling of medical waste (Table 3).

**Table 3.** Attitude of Respondents towards Medical Waste Management, Wau (n=135)

| Attitude | Variable | Frequency | % |
|---|---|---|---|
| What do you do when exposed to injury while handling medical waste? | nothing | 10 | 7.4 |
| | wash the injury sites | 52 | 38.5 |
| | report | 59 | 43.7 |
| | PEP initiation | 14 | 10.4 |
| | **Total** | **135** | **100** |
| How do you perceive waste management? Is it priority? | no critical | 4 | 3.0 |
| | important for infection control | 100 | 74.0 |
| | important for environmental safety | 31 | 23.0 |
| | **Total** | **135** | **100** |
| To what extent, safe handling of medical wastes practiced by technical staff | unsatisfactory | 26 | 19.2 |
| | satisfactory | 41 | 30.4 |
| | good | 41 | 30.4 |
| | excellent | 27 | 20.0 |
| | **Total** | **135** | **100** |
| To what extent, safe handling of medical wastes practiced by non-technical staff | non-existent | 11 | 8.1 |
| | unsatisfactory | 54 | 40.0 |
| | satisfactory | 36 | 26.7 |
| | good | 26 | 19.3 |
| | excellent | 8 | 5.9 |
| | **Total** | **135** | **100** |

## Practices of Healthcare Workers towards Medical Waste Management

Table 4 showed the common personal protective equipment (PPE) used by healthcare workers was gloves (58.5%), followed by overalls (24.4%). The incident reporting system was confirmed by 68.9% of respondents; 80.7% recapped needles before passing them on to others or disposed of them to protect others.

More than half, 53.3% (n=72), of respondents obtained vaccination against hepatitis B at their respective healthcare facilities. However, the reason for not receiving HBV vaccination was due to lack of enough resources (62.2%, n=59). Regarding medical waste disposal, the majority, 24.4% (n=33) of respondents mentioned incineration, followed by open or pit burning (24.4%, n=33).

Whether your HCF has an incinerator, Metamiser, or autoclave, less than half, 47.4% (n=64), of respondents mentioned incinerator only, and 20.7% (n=28) said incinerator, Metamiser, or autoclave. 66.7% (n = 90) of respondents agreed that healthcare HCF staff were only responsible for operating and managing the on-site incinerator. The 42.2% (n=57), of respondents suggested the transfer of medical waste to a nearby treatment facility, while 31.1% (n=42) mentioned the safe storage of medical waste. On how the HCF is fed to the incinerator, the majority, 64.4% (n=87) of respondents, said manually through the door or using a screw feeder (26.7%, n=36).

How is the ash from the incinerator disposed of? The ashes generated from the incinerators were disposed of through burying (33.3%, n=45) or open dumping (29.6%, n=40).

**Table 4.** Practice of Respondents towards Medical Waste Management, Wau (n=135)

| Practice | Variable | Frequency | % |
|---|---|---|---|
| What kind of personal protective equipment (PPE) is used by those medical staff who manage medical waste? | gloves | 79 | 58.5 |
| | heavy duty boots | 9 | 6.7 |
| | goggles | 4 | 3.0 |
| | surgical masks | 9 | 6.7 |
| | face shields | 1 | 0.7 |
| | overalls | 33 | 24.4 |
| | **Total** | **135** | **100** |
| Is there an incident reporting system in place, including needle prick injuries? | Yes | 93 | 68.9 |
| | No | 42 | 31.1 |
| | **Total** | **135** | **100** |
| Do you recap needles before passing on to others or dispose of them to protect others? | Yes | 109 | 80.7 |
| | No | 26 | 19.3 |
| | **Total** | **135** | **100** |
| Is vaccination against hepatitis B carried out for permanent/causal HCF staff? | Yes | 72 | 53.3 |
| | No | 63 | 46.7 |
| | **Total** | **135** | **100** |
| If not, please indicate the reasons for not vaccinating the HCF staff? | not enough resources | 59 | 62.2 |
| | frequent change of casual workers | 18 | 18.9 |
| | as per the government circular | 18 | 18.9 |
| | **Total** | **95** | **100** |
| How is the medical waste disposed of? | burial | 25 | 18.6 |
| | hand over to authorized third party | 18 | 13.3 |
| | incineration | 59 | 43.7 |
| | open or pit burning | 33 | 24.4 |
| | **Total** | 135 | 100 |
| Please indicate whether your HCF has an incinerator, metamiser, or autoclave | incinerator only | 64 | 47.4 |
| | metamiser only | 7 | 5.2 |
| | autoclave only | 29 | 21.5 |
| | incinerator and metamiser or (autoclave) | 28 | 20.7 |
| | none | 7 | 5.2 |
| | **Total** | **135** | **100** |
| Who is responsible for operating and managing the on-site incinerator? | HCF staff | 90 | 66.7 |
| | supplier of the facility itself | 40 | 29.6 |
| | others | 5 | 3.7 |
| | **Total** | **135** | **100** |

| | | | |
|---|---|---|---|
| What do you do when the on-site incinerator doesn't function? | transfer to a nearby treatment facility | 57 | 42.2 |
| | safe storage | 42 | 31.1 |
| | unsafe storing | 3 | 2.2 |
| | open dumping | 10 | 7.4 |
| | burial | 12 | 9.0 |
| | open burning | 11 | 8.1 |
| | **Total** | **135** | **100** |
| How is the HCF fed to the incinerator? | manually through the door | 87 | 64.4 |
| | through a screw feeder | 36 | 26.7 |
| | fully automated system | 12 | 8.9 |
| | **Total** | **135** | **100** |
| How the ash from the incinerator is is disposed of? | open dumping | 40 | 29.6 |
| | bury | 45 | 33.3 |
| | collected by the local authority | 28 | 20.7 |
| | secure land filling | 20 | 14.9 |
| | immobilized and secure land filling | 2 | 1.5 |
| | **Total** | **135** | **100** |

## Qualitative Findings

The study carried out 14 key informant interviews (KIIs) with the in-charge of health facilities, for instance: regarding the use of personal protective equipment (PPE), most informants agreed on lack of PPE and insufficient medical waste management facilities. For example, one informant from Wau Teaching Hospital said:

"*We are facing big problem here regarding medical waste management; we don't have enough waste management facilities such as waste bins, soaps, boats, overalls, gloves, etc. work is difficult… we risk our life … because what can we do. we reported … but no solution…***"Informant # 4"**

*Another informant suggested having a separate budget to buy related supplies locally: "I attended training on medical waste management last year; however, most of the things that taught us were not exist here… we can implement what they taught us… no PPE… cleaners don't have incentive and no salaries … that's why sometimes they don't come to work regularly… because no salary… no incentives… work become very difficult…* ***"Informant #12"***

Finally, the importance of training was emphasized by most of the informants:

*"Despite receiving training 2 years ago, we have new staff here that doesn't know how to handle medical waste… It's very dangerous because you can get injured or sick due to lack of knowledge and supplies… That is why I request continuous on-the-job training for all healthcare workers and cleaners… I ask the ministry and partners to support us here….* ***"Informant #3"***

## Discussion

This study provides important insight about medical waste management in healthcare settings in South Sudan, the country that is still struggling to improve its healthcare system, which entirely relies on humanitarian aid and donations to operate.

Understanding the level of knowledge, attitude, and practice among healthcare workers is critical in designing training, awareness, and management of medical waste management in South Sudan.

The current socio-demographic findings revealed a majority of younger healthcare workers with ages ranging from 20 to 40 years from all fourteen (14) healthcare facilities. During the time of data collection, a proportion of the healthcare workers interviewed were intern nurses, midwives, and clinical officers working under the supervision of senior healthcare workers at different healthcare facilities in Wau Municipality.

Regarding the knowledge of medical waste management, this study found overall good knowledge and awareness about medical waste management, for example, knowledge about medical waste and segregation according to WHO guidelines and standards. Despite this, there is still a knowledge gap among those healthcare workers who were not trained yet. These findings were consistent with a cross-sectional study conducted in Botswana (2018) among healthcare workers, which found that 67% of respondents attended training on medical waste management and 91% had good medical waste health risks [6]. On the other hand, the current findings were contrary to a study conducted in Nigeria (2011) that revealed more than half of respondents had average knowledge of medical waste management [8]. Moreover, this study agreed with study conducted in Sweden and Hungary in 2022 that showed more than half (58%) of Hungarian Healthcare workers demonstrated good knowledge of waste management guidelines, while 67% received training on waste handling and 84.0% had good knowledge of implementation of guidelines. On the contrary, Swedish healthcare workers demonstrated poor knowledge towards waste management guidelines (34.4%), training on waste handling (47.9%), and implementation of waste management guidelines (35.7%) [9, 18]. However, 40.5% lacked some knowledge at all, and the majority (87.1%) use latex gloves when handling waste [10].

The high level of knowledge found in our study may contribute to the deliberate intervention done by healthcare organizations and partners to ensure that all healthcare facilities comply with a minimum waste management standard, including training of healthcare workers.

Findings from qualitative data agreed with the previous studies and provided an important insight highlighting gaps in knowledge, waste management supplies, PPE, and training.

Importantly, this study revealed that the majority of healthcare workers had positive attitudes, for instance, perceived waste management as a priority, knew about segregation of waste, used gloves, reported any injury related to medical waste, and got vaccinated against waste-related illnesses.

This finding agreed with a study conducted in India (2016) that found most respondents agreed that medical waste should be segregated at the point where it is generated. This was consistent with the results from a study in India, where 96.9% of respondents agreed that waste should be segregated [11, 19].

These findings also agreed with a study from Botswana (2018) that found the majority of health workers had a positive attitude towards hospital waste management and only 44% had a negative attitude [6, 14]. Also, our study found a similar conclusion to a study among the Hungarian healthcare workers that revealed a good attitude towards hazardous waste disposal, labeling of containers, color coding, waste segregation, and occupation safety. Similarly, Swedish healthcare workers showed a good attitude towards hazardous waste disposal, labeling of containers, color coding, waste segregation, and occupation safety. Furthermore, the poor attitude was noted for the report of industrial accidents and safe management of waste. This finding agreed with a previous study conducted in Sweden &

Hungary (2022) that indicated a poor attitude (39.9%) on reports of industrial accidents and safe management of healthcare waste was observed [8]. This finding agreed with a study conducted in India (2025) that showed a strong positive attitude toward biomedical waste management among healthcare workers in India [12].

Regarding practices toward medical waste management, this study found the use of gloves and overalls as common personal protective equipment (PPE) used by healthcare workers in Wau Municipality. While the incident reporting system was confirmed by 68.9% of respondents, 80.7% recapped needles before passing them on to others or disposed of them to protect others. This study was consistent with studies conducted in Sweden/Hungary (2022) and India (2025) that found the majority of healthcare workers had good practices towards waste management, including following proper color-coding practices and waste segregation, and reported using PPE while handling biomedical waste management.

More than half, 53.3%, of respondents obtained vaccination against hepatitis B at their respective healthcare facilities. However, the reason for not receiving vaccination was due to lack of enough resources. This finding is contrary to a study done in India that found fewer respondents reported not following post-exposure prophylaxis protocols after experiencing needle-stick or percutaneous injuries [8, 12].

Regarding medical waste disposal, most respondents mentioned incineration, followed by open or pit burning. Whether your HCF has an incinerator, Metamiser, or autoclave, less than half of respondents mentioned incinerator only, and fewer said incinerator, Metamiser, or autoclave. This is inconsistent with a previous study conducted in India by Swetha Suram (2025) that found most respondents disposed of non-infectious waste in black containers, consistent with standard guidelines, and it agrees with waste management guidelines applied in South Sudan [13, 16]. The strength of this study relied on using a mixed approach, both quantitative and qualitative. This approach provided clear insight about medical waste management in Wau Municipality and South Sudan in general.

This study had some limitations: small sample size due to data was collected from one State only, this may limit the generalizability of the findings to other parts of South Sudan. In addition, the use of self-reported questionnaire may have introduced response bias and overestimated participants' knowledge and practices. However, KIIs were applied to complement the quantitative method. Moreover, despite the fact that the questionnaire was pretested to ensure accuracy of the questions, however, the study did not assess the reliability and validity of the questionnaire using standard statistical methods, which may affect the accuracy of the results. Finally, our study was limited to assessing the overall KAP and did not examine other important factors such as: funding, staff training or policy implementation though all these factors were described and identified.

Further studies are recommended to understand the relationship between poor medical waste management and quality of healthcare service and satisfaction of the patients and co-patients and assessing the relationship using structural equation modeling.

## Conclusion

This study revealed good knowledge and positive attitude and practice related to medical waste management and provided critical insight that will provide evidence-based information to Ministry of Health, Water, Sanitation and Hygiene (WASH) cluster partners such as UNICEF, WHO, government, and others. Therefore, on-the-job training of healthcare workers, especially interns and new recruits, and non-technical staff such as waste pickers and cleaners on medical waste management is critical. Provision of medical waste

management facilities (e.g., containers, protective personal equipment (PPE), incineration, etc.); motivation of healthcare workers, including cleaners; provision of a separate budget to handle medical waste management-related expenses; and formation of specialized waste management committees in all healthcare facilities to plan, fundraise, and supervise waste management activities.

## Conflict of Interest

The authors declare no competing interests.

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## Ethical Approval

Participation in this study was completely voluntary. All participants provided written informed consent after the purpose of the study was clearly explained and understood. The participants were informed about their right to withdraw from the study at any time without any implications. The study was approved by the Research Ethics Review Board at Texila American University and the Ministry of Health, Western Bahr el Ghazal State, Wau, South Sudan.

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## Data Availability

All the supported data are available and can be access on request from the corresponding author.

## Authors' Contributions

- Conceptualization: Emmanuel Aban Nyilek, Dr. Sonika Raj
- Formal analysis**:** Emmanuel Aban Nyilek and Peter Marin
- Methodology: Emmanuel Aban Nyilek, Dr. Sonika Raj, Peter Marin
- Writing – original draft: Emmanuel Aban Nyilek
- Writing – review & editing: Emmanuel Aban Nyilek, Dr. Sonika Raj, Peter Marin

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# Impact of a Mobile Application-Based Intervention on Mental Health and Stress Coping Strategies among Nurses: A Randomized Controlled Trial

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***Abstract*** *Health is wealth. Nurses serve as the backbone of the healthcare system. Yet, the demanding nature of clinical practice - including extended working hours, rotational shifts, low payrolls, emotional strain, and continuous exposure to occupational stressors - significantly affects their mental well-being and professional efficiency. This study aimed to evaluate the effectiveness of a mobile application-based intervention in enhancing mental health and reducing stress among nurses employed in tertiary care hospitals. A pre-test and post-test parallel-group design was adopted among 36 registered nurses selected through simple random sampling in Mangalore, Karnataka, India. Participants were allocated into intervention and control groups, with the intervention group receiving the wellness-focused mobile application for one month while the control group received standard information. Data were collected using validated instruments, including the WHO-5 Well-Being Index, Perceived Stress Scale (PSS-4), and Brief COPE Inventory. Statistical analysis incorporated descriptive and inferential measures such as paired t-tests, independent t-tests, and chi-square tests. Between-group comparisons at post-test showed that the intervention group had significantly lower stress scores and significantly higher coping scores than the control group, while mental health scores improved significantly within the intervention group over time but did not differ significantly from the control group at post-test, likely reflecting the modest sample size. These findings indicate that digital mental health strategies can meaningfully reduce stress and strengthen coping abilities among nurses, supporting further investigation of their potential to improve broader psychological well-being. This research study concludes that mobile application-based interventions offer an innovative, accessible, and cost-effective solution to enhancing mental health, stress management, and emotional well-being among nurses in healthcare settings.*

***Keywords*** *Coping Strategies, Mental Health, Mindfulness, Mobile Health Application, Nurses, Occupational Stress, Psychological Well-being.*

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## Introduction

Nursing is a noble and dedicated service. It is widely recognized as one of the most physically and emotionally demanding healthcare professions in a global arena. Nurses are responsible for continuous patient monitoring, emergency response, medication administration, communication with patients and families, and coordination of multidisciplinary health care. These responsibilities often expose nurses to excessive psychological pressure and emotional exhaustion. Long working hours, night shifts, staff shortages, heavy patient loads, workplace conflicts, and increasing healthcare demands contribute significantly to occupational stress among nurses.

Occupational stress is defined as the harmful emotional and physical response that occurs when workplace demands exceed an individual's ability to cope effectively. Persistent stress among nurses may lead to anxiety, burnout, depression, sleep disturbances, emotional fatigue, low job satisfaction, absenteeism, reduced productivity, and poor quality of patient care. In difficult situations, prolonged stress may also affect patient safety and organizational outcomes.

Mental well-being among nurses is essential for maintaining professional competence, emotional resilience, effective communication, and compassionate patient care. Nurses who are unable to cope effectively with stress are more likely to experience psychological distress and decreased work performance. Therefore, healthcare institutions increasingly recognize the importance of implementing evidence-based interventions to improve nurses' mental health and adaptive coping skills.

Recent advances in digital health technology have created new opportunities for mental health promotion and stress management. Mobile health applications offer flexible, accessible, and cost-effective psychological support through mindfulness exercises, guided meditation, relaxation techniques, stress monitoring, emotional regulation activities, and educational resources. Unlike traditional face-to-face interventions, mobile applications can be accessed conveniently at any time without interfering with work schedules.

Several international studies have reported favorable outcomes associated with digital mental health interventions among healthcare professionals. Mobile applications have demonstrated effectiveness in reducing stress, improving emotional well-being, enhancing mindfulness, and strengthening coping abilities. However, limited randomized controlled trials have specifically examined the effectiveness of mobile app interventions among nurses in Indian healthcare settings.

Pilot randomized controlled trials are important for evaluating intervention feasibility, user engagement, effectiveness, and implementation potential before large-scale adoption. Therefore, the present study was undertaken to examine the effectiveness of a structured mobile application intervention in improving mental health and stress coping strategies among nurses working in a tertiary care hospital.

## Review of Literature

Occupational stress among nurses has been extensively documented in healthcare literature. Shivaprasad reported that nurses commonly experience stress because of workload imbalance, role ambiguity, and interpersonal conflicts in healthcare settings [1]. Sharma and colleagues observed that occupational stress adversely affects nurses' psychological and physical well-being, contributing to emotional exhaustion and reduced work performance [2]. Similarly, Adriaenssens et al. identified burnout and emotional fatigue as major psychological consequences among emergency nurses exposed to prolonged stress [3].

The role of digital technologies in mental health management has received increasing attention over the last decade. Proudfoot

emphasized the growing importance of mobile phones and digital applications in mental health promotion and treatment [4].

A randomized controlled trial conducted by Watanabe et al. evaluated a smartphone-based stress management intervention among nurses during the COVID-19 pandemic in Vietnam and Thailand [5]. The study demonstrated significant improvement in depressive symptoms and emotional well-being among nurses who received the intervention.

Linardon et al. performed a meta-analysis of app-supported mental health interventions and found that mobile applications showed modest but significant improvement in stress management outcomes and psychological functioning [6]. Firth et al. also reported that smartphone-based interventions effectively reduced depressive symptoms and promoted emotional health among users [7].

Indian studies have similarly highlighted the burden of occupational stress among nurses. Pai Vernekar and Shah reported high levels of work-related stress among nurses employed in tertiary healthcare institutions [8]. Sailaxmi and Lalitha found that structured stress management programs significantly improved stress perception among psychiatric nurses [9].

Jordan et al. observed that perceived stress and inadequate coping mechanisms negatively affected nurses' overall health and professional functioning [10]. Bhatia et al. identified high occupational stress levels among nurses working in tertiary hospitals because of excessive workload and organizational demands [11].

The importance of digital mental health interventions in India has also been emphasized in recent literature. Kumar et al. discussed the growing relevance of e-mental health initiatives in India while highlighting implementation challenges such as digital literacy and accessibility [12].

Tamminga et al., demonstrated that occupational stress prevention interventions could effectively improve psychological well-being among healthcare professionals [13]. Hersch et al. reported significant stress reduction among nurses participating in a web-based stress management intervention [14]. Babapour et al. reported that occupational stress negatively affected nurses' quality of life and caring behaviors [15].

Methodological guidance for pilot randomized controlled trials in healthcare has been described by Eldridge and Kerry Cottrell also emphasized the importance of evidence-based stress assessment and intervention strategies in mental health nursing [16].

Although global evidence supporting digital mental health interventions is growing, limited experimental research has been conducted among nurses in Indian clinical settings. Therefore, the present study aimed to address this research gap.

## Need for the Study

Nurses are continuously exposed to stressful work environments that may negatively affect psychological well-being, emotional resilience, and professional performance. Persistent occupational stress contributes to burnout, absenteeism, poor patient outcomes, and decreased job satisfaction. Although healthcare organizations increasingly recognize the importance of mental health support, accessible and scalable stress management interventions remain limited.

Mobile health technologies provide flexible opportunities for delivering psychological support without interrupting clinical responsibilities. However, evidence regarding the effectiveness of mobile app-based mental health interventions among nurses in India remains inadequate. Therefore, this pilot randomized controlled trial was conducted to evaluate whether a structured mobile application could improve mental health and coping abilities among nurses.

### Theoretical Framework

The study was based on Cognitive Behavioral Theory (CBT) and Mindfulness-Based Stress Reduction (MBSR).

### Cognitive Behavioral Theory

Cognitive Behavioral Theory explains how thoughts, emotions, and behaviors influence psychological functioning. The intervention incorporated behavioral activation strategies, coping exercises, emotional regulation techniques, and positive reinforcement activities designed to improve mental well-being.

### Mindfulness-Based Stress Reduction

Mindfulness-Based Stress Reduction focuses on enhancing present-moment awareness and emotional regulation through mindfulness practices. The mobile application included guided meditation, breathing exercises, relaxation techniques, stretching activities, and mindfulness reminders to reduce stress and improve coping.

### Aim of the Study

To evaluate the effectiveness of a mobile application intervention on mental health and stress coping strategies among nurses.

### Objectives of the Study

1. To assess baseline mental health, stress levels, and coping strategies among nurses.
2. To implement a structured mobile application-based stress management intervention.
3. To compare post-intervention stress levels and coping strategies between intervention and control groups.
4. To determine the effectiveness of the intervention in improving mental health outcomes.

### Hypotheses:

H1: Nurses receiving the mobile application intervention will demonstrate significantly improved mental health, lower stress levels, and better coping strategies compared with nurses in the control group.

H2: The intervention group will show significant improvement in psychological well-being and coping abilities following the intervention.

## Materials and Methods

### Research Design

A randomized controlled trial with a parallel-group pre-test and post-test design was adopted for the study.

### Setting of the Study

The study was conducted at Fr. Muller's Charitable Hospital, Thumbay, Mangalore, India.

### Population and Sample

The target population consisted of registered nurses working in various hospital departments, including medical wards, surgical wards, intensive care units, emergency units, operating theaters, pediatric wards, obstetric and gynecological units, and psychiatric departments.

A total of 36 nurses who met the eligibility criteria participated in the study. Participants were randomly assigned to:

1. Intervention group (n = 18)
2. Control group (n = 18)

#### Inclusion Criteria

- Registered nurses employed in the hospital.
- Nurses willing to provide informed consent.
- Nurses able to operate smartphone applications.
- Nurses with at least six months of work experience.

#### Exclusion Criteria

- Nurses diagnosed with severe psychiatric disorders.
- Nurses unable to use smartphones.

- Nurses are currently participating in another mental health program.
- Nurses on prolonged leave during the study period.

## Randomization

- Participants were recruited through a digital link shared by the investigator and distributed directly via FMCI nursing leadership. This link allowed interested individuals to be assessed for eligibility.
- To ensure an unbiased distribution, simple randomization was performed with 1:1 allocation ratio. The randomization sequence was fully automated and generated by the application developer using computer-generated random numbers.
- Upon the successful completion of the informed consent process and pre-test in the digital link, the system automatically assigned the participating nurses to either the intervention or control group. To maintain study integrity and minimize contamination between groups, participants in the intervention group received restricted, authenticated access using participant number and password to the mobile application.

## Description of the Intervention

Participants in the intervention group received access to the SHANTHI mobile application for a duration of six weeks, with instructions to engage with the content daily for approximately 10 to 30 minutes. To ensure strict intervention fidelity, user engagement was tracked via an administrative backend dashboard that logged individual session completions and precise total daily usage duration. Automatic reminders to use the app were sent out daily along with motivational quotes to encourage users to engage with the app (Figure 1 to 3).

| Category | Metric | Value |
|---|---|---|
| EXPORT INFORMATION | | |
| | Export Date | 12/3/2025, 1:18:57 PM |
| | Export Filter | All Participants |
| PARTICIPANT OVERVIEW | | |
| | Active Participants | 41 |
| | Intervention Group | 23 |
| | Control Group | 18 |
| | Demographics Completed | 35 |
| APP USAGE STATISTICS | | |
| | Total App Sessions | 212 |
| | Average Session Duration (min) | 8 |
| | Total Session Time (hours) | 29.3 |
| PRETEST ASSESSMENT | | |
| | Total Pretest Responses | 41 |
| | Registered Nurses | 41 |
| | Consented Participants | 41 |
| | WHO-5 Average Score (%) | 80.5% |
| | PSS-4 Average Score | 9.6 |
| POSTTEST ASSESSMENT | | |
| | Total Posttest Responses | 36 |
| | Posttest Completion Rate (%) | 88% |
| | WHO-5 Average Score (%) | 82.9% |
| | PSS-4 Average Score | 9.3 |
| | Responses with Feedback | 9 |
| DEMOGRAPHICS SUMMARY | | |
| | Total Demographics Surveys | 35 |

**Figure 1.** Research Dashboard Summary

https://doi.org/10.21522/TIJAR.2014.13.03.Art022

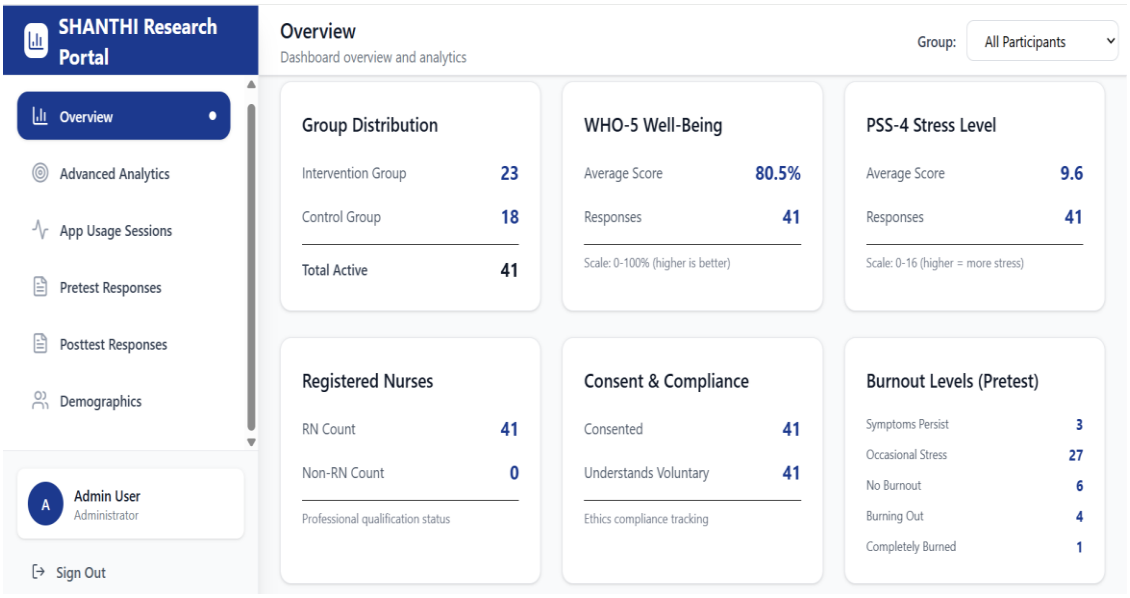


**Figure 2.** Administrative Backend Dashboard

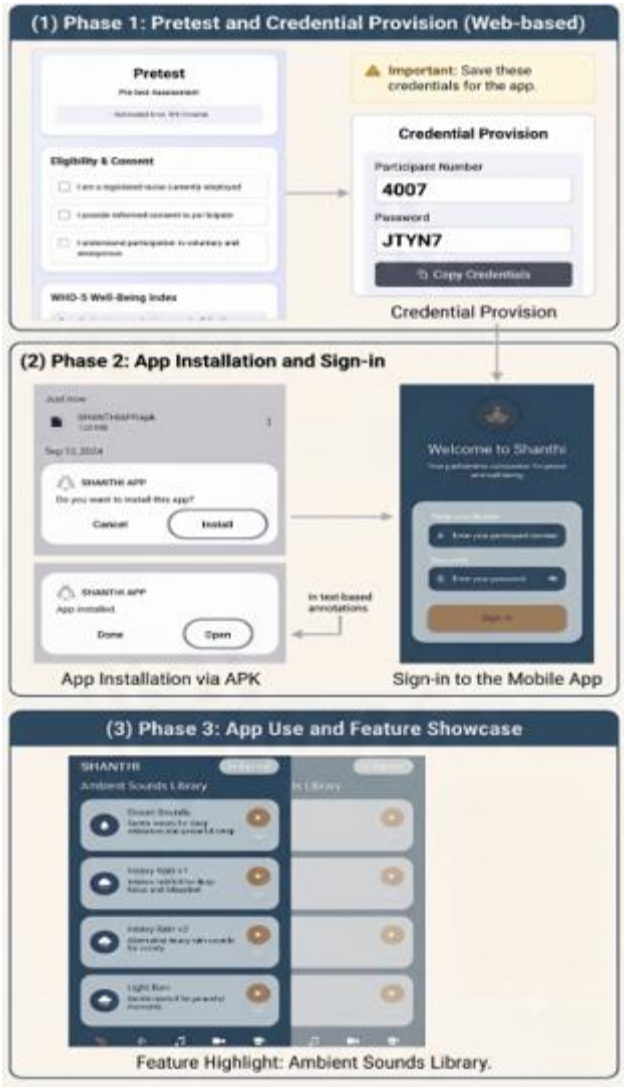


**Figure 3.** User Flow of SHANTHI App

The app included:

- Guided meditation sessions
- Mindfulness exercises
- Breathing technique guides
- Educational courses on stress management and other self-care
- Motivational reminders and app achievements

Participants were encouraged to use the application daily for approximately 10-30 minutes.

The control group received general wellness education without access to the mobile application.

### Data Collection Tools:

The investigator used the following for data collection:

- Socio-demographic questionnaire
- WHO-5 Well-Being Index
- Perceived Stress Scale (PSS-4)
- Brief COPE Inventory
- App usage records

### Validity and Reliability

Standardized instruments with established validity and reliability were used in the study. The WHO-5 Well-Being Index, PSS-4, and Brief COPE Inventory have demonstrated satisfactory psychometric properties in previous studies.

### Ethical Considerations

Ethical approval was obtained from the Institutional Ethics Committee before data collection. Written informed consent was obtained from all participants. Confidentiality and anonymity were maintained throughout the study. Participation was voluntary, and participants had the right to withdraw at any stage.

### Statistical Analysis

Data were analyzed using descriptive and inferential statistical methods. Frequency, percentage, mean, and standard deviation were used for descriptive analysis. Chi-square tests were applied to assess baseline homogeneity between groups. Paired t-tests and independent t-tests were used to evaluate intervention effectiveness. Statistical significance was considered at $p < 0.05$.

## Results

### Demographic Characteristics:

The intervention and control groups were comparable with respect to age, gender, marital status, educational qualification, years of experience, salary, working department, shift pattern, and residence. Chi-square analysis demonstrated no statistically significant differences between groups at baseline, indicating homogeneity.

### Comparison of Mean Post-test Mental Health, Stress and Coping Strategies Levels between Intervention and Control Groups

**Table 1.** Comparison of Mean Post-test Level of Mental Health, Stress and Coping Strategies between Experimental and Control Group

**N=18**

| Variables | Point of testing | Group | Mean | SD | SEM | MD | df | 't' Value | 'p'Value |
|---|---|---|---|---|---|---|---|---|---|
| Mental Health | Posttest | Exp | 17.611 | 3.416 | 0.805 | 1.333 | 34 | 1.190 | 0.242* |
| | | Con | 16.278 | 3.304 | 0.778 | | | | |
| Stress | Posttest | Exp | 5.833 | 2.618 | 0.617 | -5.111 | 34 | 5.684 | 0.001*** |
| | | Con | 10.944 | 2.775 | 0.654 | | | | |
| | Posttest | Exp | 45.222 | 7.125 | 1.679 | 17.833 | 34 | 8.797 | 0.001*** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Coping Strategies | | Con | 27.389 | 4.816 | 1.135 | | | | |

**** Very highly significant, ** Highly significant, * Not significant, Exp-Experimental group, Con-Control group*

## Mental Health Outcomes

The comparison of mental health scores between the intervention and control groups before and after the intervention is presented in Table 1.

**Table 2.** Comparison of Mental Health Scores Between Groups

| Group | Pre-test Mean ± SD | Post-test Mean ± SD | t-value | p-value |
|---|---|---|---|---|
| Intervention Group | 15.167 ± 5.171 | 17.611 ± 3.415 | 2.518 | 0.022** |
| Control Group | 15.833 ± 3.823 | 16.278 ± 3.304 | -1.458 | 0.163 |

**** Very highly significant, ** Highly significant, * Not significant*

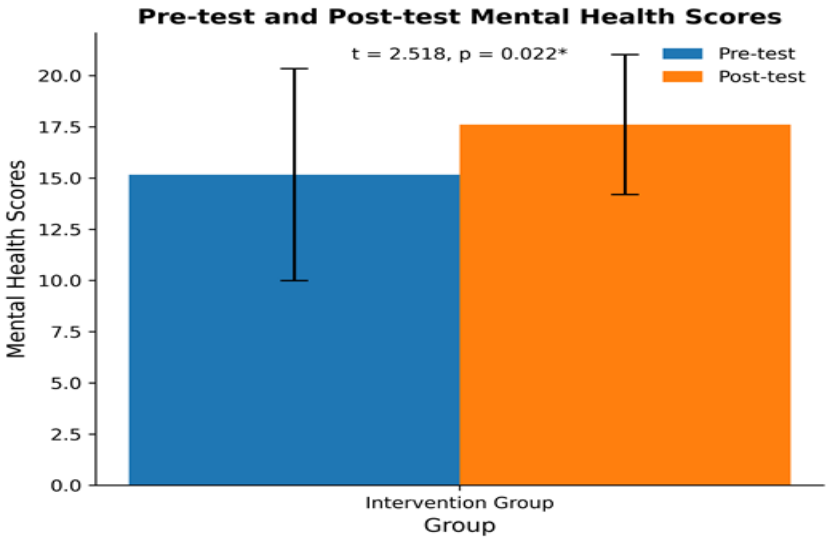


**Figure 4.** Comparison of Mental Health Scores within Intervention Group between Pre-test and Post-test

The intervention group demonstrated statistically significant improvement in mental health scores following the six-week intervention period (t(17) = 2.518, p = 0.22) (See Figure 4). However, the between-group comparison of post-test mental health scores was not statistically significant (t(34) = 1.190, p = 0.242), indicating that this within-group improvement did not translate into a significant advantage over the control group. (See Table 2).

## Stress Outcomes

**Table 3.** Comparison of Stress Outcomes Between Groups

| Group | Pre-test Mean ± SD | Post-test Mean ± SD | t-value | p-value |
|---|---|---|---|---|
| Intervention Group | 10.333 ± 1.847 | 5.833 ± 2.618 | 8.667 | 0.001*** |
| Control Group | 10.556 ± 1.653 | 10.944 ± 2.776 | -0.642 | 0.529* |

**** Very highly significant, ** Highly significant, * Not significant*

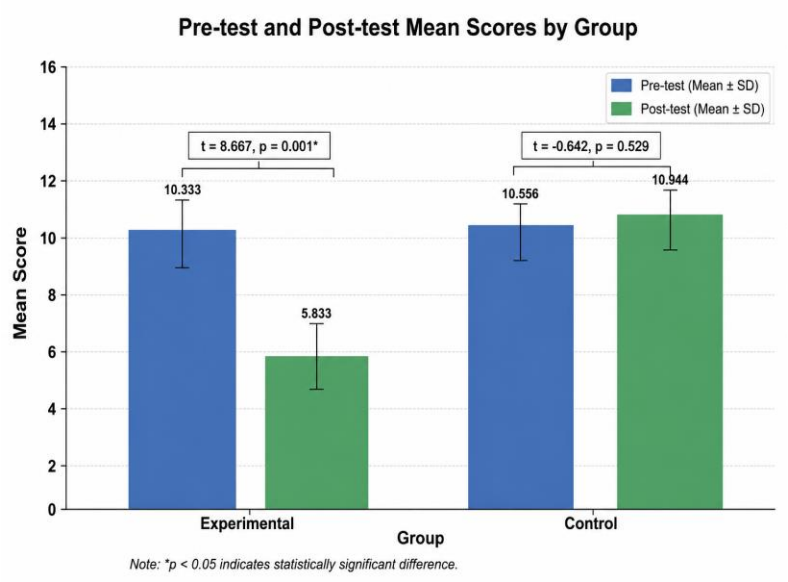


**Figure 5.** Comparison of Stress Scores between Groups after the Intervention

The intervention group demonstrated a significant reduction in perceived stress scores from pre-test to post-test ($t(17) = 8.667$, $p = 0.001$), whereas no significant change occurred in the control group ($t(17) = -0.642$, $p = 0.529$). (See Figure 5) The intervention group also had significantly lower stress scores than the control group at post-test ($t(34) = 5.684$, $p = 0.001$) (See Table 3).

## Coping Strategy Outcomes

**Table 4.** Comparison of Coping Strategies Between Groups

| Group | Pre-test Mean ± SD | Post-test Mean ± SD | t-value | p-value |
|---|---|---|---|---|
| Intervention Group | 28.444 ± 5.628 | 45.222 ± 7.125 | 7.892 | 0.001*** |
| Control Group | 28.278 ± 3.893 | 27.389 ± 4.816 | 1.16 | 0.262* |

**** Very highly significant, ** Highly significant, * Not significant*

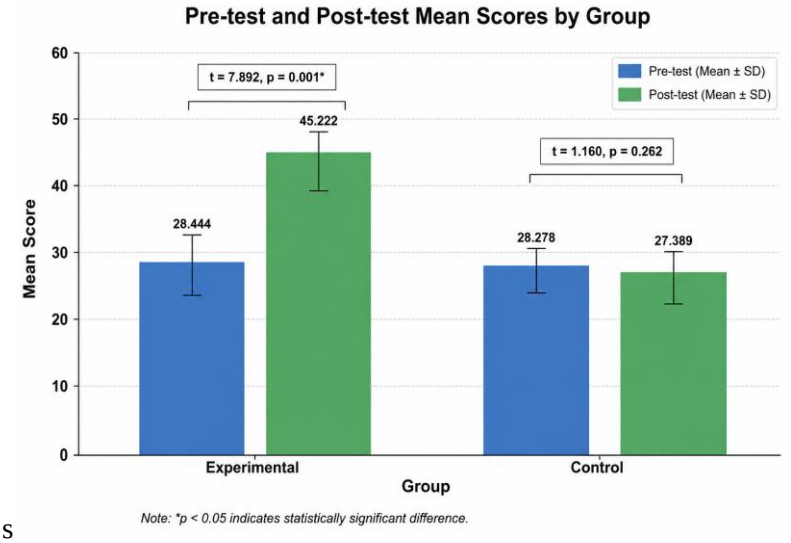


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**Figure 6.** Comparison of Coping Strategies

Coping strategy scores improved significantly in the intervention group from pre-test to post-test ($t(17) = 7.892$, $p = 0.001$), while the control group showed no significant change ($t(17) = 1.160$, $p = 0.262$) (See figure 6). The intervention group also scored significantly higher on coping than the control group at post-test ($t(34) = 8.797$, $p = 0.001$) (See Table 4). Nurses who used the mobile application demonstrated greater use of adaptive coping mechanisms and improved emotional regulation abilities.

### Association Between Demographic Variables and Study Variables

Significant associations were identified between mental health scores and gender ($p = 0.022$), as well as frequency of night shifts ($p = 0.041$). Coping strategy outcomes were significantly associated with educational qualification ($p = 0.027$) and working hours ($p = 0.019$). No significant association was observed between stress scores and demographic variables.

## Discussion

The present study evaluated the effectiveness of a structured mobile application intervention in improving mental health and stress coping strategies among nurses working in a tertiary healthcare institution. The findings demonstrated significant improvement in psychological well-being, substantial reduction in perceived stress, and enhancement of coping abilities among participants who received the intervention.

The observed reduction in stress scores among nurses in the intervention group supports previous findings reported in international literature. Watanabe et al. demonstrated that smartphone-based stress management interventions significantly improved depressive symptoms and emotional well-being among nurses during the COVID-19 pandemic [6]. Similarly, Linardon et al. concluded that app-supported mental health interventions effectively improved stress management and psychological functioning [7].

Part of the improvement in coping and stress scores observed in the present study is consistent with cognitive-behavioral mechanisms of change. The Cochrane review by Tamminga et al. categorises individual-level occupational stress interventions into those that work by modifying an individual's thoughts, feelings, and behaviour around a stressor, and those that work by directing attention away from the stress experience through relaxation or other disengagement strategies [13]. This review inspires the CBT-based and mindfulness-based components built into the SHANTHI application. Consistent with this cognitive-behavioural pathway, Watanabe et al.'s smartphone-based program for nurses was structured around established CBT techniques including self-case formulation, behavioral activation, and cognitive restructuring, which produces measurable reductions in depressive symptoms [6].

The SHANTHI application used these mechanisms through its educational courses on stress management and self-care, which helped nurses identify and reframe unhelpful appraisals of workplace stressors. Furthermore, the automated system of daily motivational reminders and app achievements functioned as behavioral activation tools, which encourages consistent interaction and reinforces adaptive behavioral responses through repeated practice. These aspects provide a plausible explanation for why coping showed the largest and most robust between-group effect in this study ($t = 8.797$).

Simultaneously, the improvement in coping abilities may be attributed to the guided meditation sessions, mindfulness exercises, and breathing technique guides incorporated into the SHANTHI application. These components correspond directly to the "attention-away" category of stress intervention described by Tamminga et al., which aims to alleviate the

emotional experience of stress directly rather than changing the cognitive evaluations that give rise to it [13]. Within the app interface, these structured exercises work by cultivating present-moment awareness and a more accepting, non-reactive stance toward stressful thoughts, while the breathing guides provide an immediate physiological anchor to down-regulate acute autonomic arousal during high-pressure shifts. Over the six-week intervention, this repeated daily practice supports better emotional regulation, self-awareness, and resilience among healthcare professionals.

The SHANTHI app utilizes both the CBT coursework that alters the cognitive appraisal producing stress and the mindfulness features that modify the immediate emotional response to it to produce a combined and improved overall effectiveness of coping competencies, which stems the consistent coping improvement than the overall mental health indicators did on their own.

The flexibility and accessibility of mobile health applications make them particularly suitable for nurses who often experience irregular schedules and high workload demands. Unlike traditional face-to-face counseling programs, mobile applications provide immediate psychological support without disrupting clinical responsibilities.

Another important finding of the study was the positive user engagement observed among nurses using the mobile application. Participants reported that the intervention was easy to access, convenient to use, and helpful for stress management. These findings suggest that digital mental health interventions may achieve good acceptability among healthcare professionals when designed using user-friendly and evidence-based approaches.

The present study findings also support the growing integration of digital wellness interventions into occupational health programs. Healthcare institutions may consider implementing structured mobile mental health initiatives to improve employee well-being, reduce burnout, increase resilience, and enhance staff retention.

Between-group comparisons at post-test confirmed that the intervention group achieved significantly greater reductions in stress ($t(34) = 5.684$, $p = 0.001$) and significantly greater gains in coping ($t(34) = 8.797$, $p = 0.001$) than the control group. For mental health however, even though the intervention group improved significantly within itself over the six-week period ($t(17) = 2.518$, $p = 0.022$), this improvement did not translate into a statistically significant advantage over the control group at post-test ($t(34) = 1.190$, $p = 0.242$) (See Table 1). This may be related to the limited sample size and short duration of the intervention, both of which reduce the power to detect between-group effects even when a genuine trend toward improvement is present. Longitudinal studies with larger populations are required to evaluate long-term effectiveness on mental well-being specifically.

The study has several limitations. First, the sample size was relatively small and limited to a single healthcare institution, which may affect generalizability. Second, the intervention period lasted only six weeks. Third, self-reported questionnaires may introduce reporting bias. Future multicenter randomized controlled trials with larger samples and extended follow-up periods are recommended.

Despite these limitations, the findings contribute valuable evidence regarding the potential effectiveness of mobile mental health interventions among nurses in Indian healthcare settings.

## Conclusion

The mobile application-based intervention was effective in improving psychological well-being, reducing perceived stress, and enhancing coping strategies among nurses. Nurses who participated in the intervention demonstrated significant improvement in emotional health and adaptive coping abilities following the six-week intervention period.

The findings suggest that mobile mental health applications can serve as practical, accessible, and cost-effective tools for supporting occupational mental health among healthcare professionals. Incorporating evidence-based digital wellness programs within healthcare institutions may contribute to improved employee well-being, resilience, and quality of patient care.

Further large-scale randomized controlled trials are recommended to confirm the effectiveness of mobile app interventions and support broader implementation within healthcare systems.

## Nursing Implications

### Clinical Implications

Mobile health interventions may be integrated into workplace wellness initiatives to support nurses experiencing occupational stress and emotional fatigue.

### Educational Implications

Nursing education programs should include digital mental health literacy, mindfulness training, and stress management competencies and strategies to prepare nurses for demanding clinical environments.

### Administrative Implications

Healthcare administrators may consider implementing structured digital wellness programs to improve employee satisfaction, productivity, resilience, and retention.

### Research Implications

The present pilot study provides a foundation for future large-scale research exploring digital mental health interventions among healthcare professionals in different settings and populations.

## Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

## Funding

No external funding was received for this study. The research was conducted independently as part of academic research work.

## Conflict of Interest

The author declares no conflict of interest related to this study.

## Ethical Approval

Ethical approval for the study was obtained from the Institutional Ethics Committee before commencement of data collection.

## Author Contributions

The investigator contributed to conceptualization, methodology, data collection, statistical analysis, interpretation of findings, manuscript preparation, and final review of the study.

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# Household, Faith, and Community Support as Enablers of Antenatal Care Completion in a Fragile Urban Setting of Eastern Democratic Republic of Congo

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***Abstract*** *Antenatal care (ANC) completion is influenced by health-service factors as well as household and community support systems. This study examined whether partner encouragement, faith-leader messages, religious activities and participation in women's or community groups were associated with ANC completion among host community women in Karisimbi. A cross-sectional analysis was conducted using data from 715 eligible women who had given birth in the past 12 months and were selected through multistage household sampling. The main outcome were completion of at least four ANC contacts (ANC4+) and a minimum of eight ANC contacts (ANC8+). Key explanatory variables included partner encouragement, exposure to faith-leader messages promoting ANC, frequency of religious activities and participation in women's or community groups. Multivariable logistic regression models were used, adjusting for maternal age, education, household assets, and access-related barriers. ANC4+ completion was 65.8%, while ANC8+ completion was 6.0%. In adjusted models, partner encouragement was associated with higher odds of ANC4+ completion (AOR 3.66; 95% CI 2.32-5.77), as was exposure to faith-leader ANC messages (AOR 2.03; 95% CI 1.13-3.63). Women/community group participation was positively but not significantly associated with ANC8+ completion (AOR 2.27; 95% CI 0.71-7.28). Partner encouragement and faith-leader communication may serve as practical entry points for improving ANC continuity in Karisimbi. Maternal health interventions in fragile urban settings should strengthen household and faith-community engagement to support sustained ANC attendance.*

***Keywords*** *Antenatal Care Completion, Community Engagement, Democratic Republic of Congo, Faith Leaders, Partner Encouragement, Women's Groups.*

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## Introduction

Maternal mortality Antenatal care (ANC) is a foundational public health intervention because it creates repeated opportunities to detect pregnancy complications, prevent avoidable morbidity, provide counselling, link women to skilled birth care and enhance compliance of women in pregnancy. The global policy change from the former four-visit (ANC4+) approach to a minimum of eight contacts (ANC8+) was not only a numerical change; it reflected accumulated evidence that respectful, timely and clinically meaningful contact during pregnancy can improve perinatal outcomes and strengthen women's confidence in care [1–3].

The DRC remains a high-priority maternal health context because global maternal mortality has become increasingly concentrated in sub-Saharan Africa and in countries experiencing conflict, institutional fragility and constrained health systems. The 2025 inter-agency estimates report that approximately 260,000 women passed away around the world from gestation or childbirth-related causes in 2023. Many of these fatalities occurred in sub-Saharan Africa which show fragile settings carrying disproportionate risk. Such estimates justify local epidemiological studies that move beyond national averages to identify modifiable determinants within specific health zones [4–6].

Karisimbi Health Zone is a valuable site for studying household and community enablers because the setting combines urban density, population mobility, recurrent insecurity, informal household economies and crowded health services. Host-community women may not be registered in formal internally displaced-person camps, yet they are exposed to many of the same pressures that shape care seeking in humanitarian environments: uncertain income, transport constraints, safety concerns, health-worker workload and commodity shortages. These conditions make it essential to distinguish between first contact with ANC and sustained continuity of care [4, 7, 8].

In settings where religious affiliation and participation are socially important, faith-based networks can influence maternal health behavior by using trusted leaders, congregational platforms, household outreach, counselling, and repeated health education messages to promote antenatal care and facility delivery [9–12].

Trained religious leaders have been shown to improve maternal health service utilization when their messages are linked to formal health services: in Ethiopia, faith leader engagement increased optimal ANC/ANC4+ use and institutional delivery, while another cluster-randomized trial pairing Orthodox priests with community health workers increased ANC4+ and facility deliveries [9, 10].

These effects appear to operate through several mechanisms, including trust in religious authority, community mobilization, home visits, dialogue with families, referral encouragement, and the ability of faith actors to translate biomedical recommendations into locally acceptable messages [9–12].

However, religious influence should not be treated as automatically beneficial, because available evidence shows that religion itself may be minimally associated with ANC barriers in some contexts, while in others religious or cultural expectations, gender norms, provider preferences, or advice from religious/traditional authorities may contribute to delayed or constrained care-seeking [13].

For this reason, examining faith-based influence together with household and community support is important for understanding socially embedded enablers of ANC completion in fragile urban settings, where women's care-seeking is shaped not only by service availability but also by trust, family decision-making, social norms, mobility constraints and community-level mediation [11, 12].

Global monitoring often reports ANC4+ because household-survey data for at least four contacts are more widely available than

comparable ANC8+ data. However, ANC4+ does not measure technical quality, content of care, provider competence, respectful communication or facility readiness. Recent effective-coverage work shows that contact coverage may be high while readiness-adjusted and quality-adjusted coverage are substantially lower; therefore, a woman's reported number of contacts should be interpreted as an entry point into quality analysis rather than as proof of adequate care [5, 14, 15].

The analytical contribution of the present study is its explicit continuum framing. Rather than treating ANC as a single binary outcome, the analysis examines timely initiation, ANC4+ and ANC8+ as related but distinct outcomes. This matters because early initiation creates the calendar space for later contacts, ANC4+ remains a useful historical and programmatic benchmark, and ANC8+ reflects current world health organization (WHO) guidance. However, few studies have examined ANC completion across this continuum while simultaneously assessing household support, faith-based influence and community participation in fragile urban settings of eastern DRC [2, 5, 16]. This study therefore assesses household, faith and community support as enablers of ANC completion among host-community women in Karisimbi Health Zone, Goma. By integrating these interconnected social domains, the study aims to generate locally grounded evidence for maternal health interventions that combine quality ANC services with trusted social support systems.

## Materials and Methods

### Study Design

In the host community of Karisimbi Health Zone, this study relied on an analytical cross-sectional household survey plan to evaluate factors related to antenatal care (ANC) attendance among recently delivered women. The analysis examined three ANC outcomes timely ANC initiation, completion of at least four ANC contacts (ANC4+), and completion of minimum eight ANC contacts (ANC8+) with particular attention to household support, faith-based exposure, and community participation.

### Study Setting and Period

We run this study from 1st to 10th May 2026 in the Karisimbi Health Zone of Goma, North Kivu Province, eastern DRC. Karisimbi is an urban health zone with an estimated population of 701,509 inhabitants. The zone faces several contextual challenges, including frequent population movement, reliance on informal livelihoods, growing demand for health services, and persistent insecurity [17, 18].

### Study Population

The source population comprised women aged 18-49 years residing in the host community of Karisimbi Health Zone who gave birth within the 12 months prior the survey. Women have been included if they were aged 18 to 49 years, had delivered during the recall period of 12 months, lived in the host community and gave informed permission. Women were excluded if they declined or did not consent, were classified as internally displaced persons for this host-community analysis or had duplicate or irreconcilably inconsistent records. The cleaned dataset contained 717 imported records; after exclusion of two ineligible records, 715 women were included in the final analysis.

### Sampling Frame and Sample Size

The health-area population served as the sampling frame and was used as the best available denominator for proportional allocation because reliable pre-field estimates of pregnant or recently delivered women were unavailable. The minimum size of sample was calculated with a 95% confidence level, 5% margin of error, presumed prevalence of 50%, design effect of 1.5 and 10% compensation for non-response. The first estimate of sample was made using:

$$n_0 = \frac{Z^2\, p\, (1-p)}{d^2}$$

where $Z = 1.96$, $p = 0.50$, and $d = 0.05$. This produced a minimum simple random sample of approximately 384 participants. After applying the design effect and expected no-answer adjustment, the required sample increased to approximately 642 participants. The achieved analytic sample of 715 women exceeded this minimum.

## Sampling Procedure

A multistage sampling design was used. All 20 health areas in Karisimbi Health Zone were included as strata. Within each health area, clusters were chosen using probability proportional to size. The number of participants allocated to each health area was calculated as:

$$n_i = \frac{N_i}{N} \times n$$

where $n_i$ was the allocated sample for health area $i$, $N_i$ the population of health area $i$, $N$ the total health-zone population, and $n$ the target sample size. Final allocation was adjusted using the largest remainder method to maintain the total target sample.

Within selected clusters, households were sampled using systematic random sampling when a household list was available. Where no complete household list existed, rapid segmentation and mapping were applied to support probabilistic household selection and reduce interviewer discretion. Eligible women aged 18 to 49 years were chosen in selected households. If more than one eligible woman was present, one respondent was selected using a Kish grid or simple random method. At least two revisits were conducted before replacement when a selected eligible participant was absent. These procedures are consistent with standard household-survey methods intended to reduce selection bias [19, 20].

## Data Collection

Data was collected with a structured household questionnaire administered in French or Kiswahili, depending on the respondent's preferred language. The questionnaire captured sociodemographic characteristics, reproductive history, when antenatal care attendance started, how many contact was achieved, partner encouragement, exposure to antenatal care-related messages from faith leaders, participation in women's or community groups, and engagement in religious activities. Prior to field implementation, the tool was pilot tested to assess item clarity, sequencing, and contextual relevance.

## Outcome Variables

Three binary ANC outcomes were analyzed. Timely ANC initiation was defined as the first ANC contact in the first trimester. ANC4+ was defined as equal or more than four ANC contacts during the index pregnancy. ANC8+ was defined minimum ANC contacts, consistent with the current WHO ANC model [2].

## Independent Variables

Independent variables were selected according to the study objectives, behavioral model of health-services use and prior evidence on ANC utilization in sub-Saharan Africa [21, 22]. Variables included maternal age, education, asset score, parity, partner encouragement, exposure to ANC messages from faith leaders, participation in women's or community groups and religious activity.

## Data Management and Variable Construction

Data were input and run through IBM SPSS Statistics version 25. Before analysis, the dataset was reviewed for completeness, internal consistency and plausibility. ANC4+ and ANC8+ indicators were re-derived from the cleaned ANC contact count rather than relying on pre-entered binary variables. Parity values exceeding gravidity were corrected where internally consistent reproductive-history information was available. Because income non-response was high, income was not used as the main socioeconomic adjustment variable;

education and asset score were used as more stable indicators of socioeconomic position.

## Statistical Analysis

Descriptive statistics summarized respondent characteristics, exposures and ANC outcomes. Categorical variables were reported as frequencies and percentages. Continuous variables were outlined using averages and standard deviations or medians and interquartile ranges, contingent upon their distribution.

Bivariable analyses described crude associations between independent variables and each ANC outcome.

Multivariable logistic regression estimated adjusted odds ratios, 95% CI and p-values for timely ANC initiation, ANC4+ and ANC8+. Logistic regression was appropriate because the outcomes were binary. Covariate selection was guided by epidemiological plausibility, prior literature review [21]. All models were evaluated for multicollinearity using variance inflation factors (VIF), discrimination assessed via the area under the receiver-operating characteristic curve (AUC), and calibration evaluated using the Hosmer-Lemeshow goodness-of-fit test as needed.

## Equations

Separate multivariable logistic regression models were fitted for each ANC outcome: timely ANC initiation, ANC4+ attendance, and ANC8+ attendance. For outcome $k$, the model was specified as:

$$\text{logit}\{P(Y_k = 1)\} = \log\left(\frac{P(Y_k = 1)}{1 - P(Y_k = 1)}\right) = \beta_{0k} + \beta_k^T \text{X}$$

where:

$$k \in \{1,2,3\}$$
$$Y_1 = \text{timely ANC initiation}$$
$$Y_2 = \text{ANC4+ attendance}$$
$$Y_3 = \text{ANC8+ attendance}$$

and X represents the vector of covariates included in each model:

X = (maternal age, education, household asset score, parity, partner encouragement, faith-leader ANC message exposure, women/community group participation, religious activity).

The corresponding predicted probability for each outcome was:

$$P(Y_k = 1) = \frac{\exp\,(\beta_{0k} + \beta_k^T \text{X})}{1 + \exp\,(\beta_{0k} + \beta_k^T \text{X})}$$

Adjusted odds ratios were obtained as:

$$\text{aOR}_{jk} = \exp\,(\beta_{jk})$$

## Bias Mitigation

Several procedures were used to reduce bias. Stratification by health area and multistage household sampling improved geographic coverage. Systematic household selection, probabilistic segmentation where household lists were unavailable, and random selection of one eligible respondent per household reduced selection bias. The 12-month recall period limited recall error compared with longer birth-history windows. Standardized questionnaire administration in French or Kiswahili improved comprehension. Data-cleaning procedures reduced misclassification of ANC outcomes and minimized the influence of implausible values. Nevertheless, residual bias may remain because ANC timing, number of contacts and service experience were self-reported. Social-desirability bias may have led to over-reporting of recommended ANC behaviors, and women with difficult pregnancy or delivery experiences may have recalled access barriers differently.

# Results

A total of 715 women were included in the analytic sample. A comparatively young reproductive-age population was indicated by the mean maternal age of 29.5 years (SD: standard deviation = 6.3) and the median age of 29 years (IQR: interquartile range 25–34). The average parity among women was 3.3 children (SD = 1.9).

Socioeconomic conditions varied moderately, with a mean household asset score of 2.5 out of 4 (SD = 1.1), and a median of 3. Partner support for antenatal care was relatively

high, with a mean encouragement score of 4.0 (SD = 1.0).

In terms of education, many women had attained at least secondary education (62.1%), while 20.1% had higher education. A smaller proportion had only primary education (13.7%) or no formal education (4.1%).

Slightly more than half of the women (53.6%) reported exposure to antenatal care (ANC) messages delivered by faith leaders. Participation in women's or community groups was also common, reported by 59.2% of participants.

Religious engagement was high in this population, with many women attending religious activities weekly (78.1%), while smaller proportions reported daily (7.7%), rare (11.2%), or no participation (2.9%) "Table 1".

**Table 1.** Characteristics of Women included in the Analytic Sample (N = 715)

| Characteristic | Non-missing N | Mean (SD) or n (%) | Median (IQR) | Observed Range |
|---|---|---|---|---|
| Maternal age (years) | 715 | 29.52 (6.29) | 29 (25-34) | 18-49 |
| Household asset score (0-4) | 715 | 2.47 (1.10) | 3 (2-3) | 0-4 |
| Parity (number of live births) | 715 | 3.26 (1.94) | 3 (2-4) | 0–12 |
| Partner encouragement (Likert scale 1-5) | 713 | 4.01 (1.03) | 4 (4-5) | 1-5 |
| **Education level** | | | | |
| None | 715 | 29 (4.1%) | - | - |
| Primary | 715 | 98 (13.7%) | - | - |
| Secondary | 715 | 444 (62.1%) | - | - |
| Higher | 715 | 144 (20.1%) | - | - |
| **Exposure to ANC messages from faith leaders** | | | | |
| No | 713 | 331 (46.4%) | - | - |
| Yes | 713 | 382 (53.6%) | - | - |
| **Women/community group participation** | | | | |
| No | 714 | 291 (40.8%) | - | - |
| Yes | 714 | 423 (59.2%) | - | - |
| **Religious activity** | | | | |
| Never | 712 | 21 (2.9%) | - | - |
| Rarely | 712 | 80 (11.2%) | - | - |
| Weekly | 712 | 556 (78.1%) | - | - |
| Daily | 712 | 55 (7.7%) | - | - |

*"-" indicate that statistic non applicable.*

ANC utilization declined substantially across the continuum from four to eight contacts. Among women with available data, 39.9% initiated ANC during the first trimester (285/714; 95% CI: 36.4-43.6), while 65.8% attended at least four ANC contacts (469/713; 95% CI: 62.2-69.2). However, completion of the WHO-recommended eight-contact schedule was uncommon, with only 6.0% of women achieving ANC8+ (43/713; 95% CI: 4.5-8.0) "Table 2".

**Table 2.** Prevalence of Antenatal Care Outcomes among Women

| Outcome | n/N | % (95% CI) |
|---|---|---|
| Timely ANC initiation | 285/714 | 39.9 (36.4–43.6) |
| ≥4 ANC visits | 469/713 | 65.8 (62.2–69.2) |
| ≥8 ANC visits | 43/713 | 6.0 (4.5–8.0) |

*Note. CI, confidence interval.*

In the multivariable model, timely ANC initiation was positively associated with maternal age, education, household asset score, and partner encouragement, and negatively related with parity and frequency of religious activity. Each additional year of maternal age was associated with higher odds of timely initiation (aOR:1.04; 95% CI: 1.01-1.07; p = 0.024). Higher educational attainment was associated with increased odds of timely initiation (aOR:1.63 per higher category; 95% CI: 1.25-2.13; p < 0.001), as was higher household asset score (aOR:1.21 per unit increase; 95% CI: 1.03-1.42; p = 0.018). In contrast, each additional live birth was related with lower likelihood of timely initiation (aOR: 0.80; 95% CI: 0.71–0.90; p <0.001). Partner encouragement was positively related with timely initiation (aOR: 1.22 per one-point increase; 95% CI: 1.03–1.45; p=0.021), whereas frequency of religious activity was negatively associated with this outcome (aOR: 0.71; 95% CI: 0.52–0.96; p = 0.026).

For ANC4+ attendance, maternal age, education, and partner encouragement remained statistically significant. Each additional year of maternal age was associated with higher odds of ANC4+ attendance (aOR: 1.04; 95% CI: 1.01–1.08; p = 0.022). Higher education was strongly associated with ANC4+ attendance (aOR: 1.79 per higher category; 95% CI: 1.38–2.31; p < 0.001). Partner encouragement was also positively linked with ANC4+ attendance (aOR: 1.60 for every one-point rise; 95% CI: 1.35–1.90; p < 0.001).

For ANC8+ attendance, partner encouragement was the only variable independently associated with the outcome. Each one-point increase in partner encouragement was associated with higher odds of completing minimum eight ANC contacts (aOR: 1.59; 95% CI: 1.03–2.46; p = 0.037). No other covariates showed statistically significant adjusted associations with ANC8+ attendance.

Exposure to ANC-related messages from faith leaders and participation in group activities were not independently associated with timely ANC initiation, ANC4+ attendance, or ANC8+ attendance in the adjusted analyses “Table 3”.

**Table 3.** Multivariable Logistic Regression Models of Antenatal Care Outcomes

| Predictor | Non-missing N | Adjusted OR (95% CI) | p-value |
|---|---|---|---|
| **Timely ANC initiation** | | | |
| Maternal age, years | 708 | 1.04 (1.01-1.07) | 0.024 |
| Education level, ordinal; none = 0 to higher = 3 | 708 | 1.63 (1.25-2.13) | <0.001 |
| Household asset score, 0–4 | 708 | 1.21 (1.03-1.42) | 0.018 |
| Parity, live births | 708 | 0.80 (0.71-0.90) | <0.001 |
| Partner encouragement, Likert scale 1–5 | 708 | 1.22 (1.03-1.45) | 0.021 |

| | | | |
|---|---|---|---|
| ANC messages from faith leaders, yes vs no | 708 | 1.37 (0.91-2.04) | 0.130 |
| Women/community group participation, yes vs no | 708 | 0.75 (0.50-1.12) | 0.155 |
| Religious activity, ordinal; never = 0 to daily = 3 | 708 | 0.71 (0.52-0.96) | 0.026 |
| **ANC4+** | | | |
| Maternal age, years | 707 | 1.04 (1.01-1.08) | 0.022 |
| Education level, ordinal; none = 0 to higher = 3 | 707 | 1.79 (1.38–2.31) | <0.001 |
| Household asset score, 0-4 | 707 | 0.96 (0.81-1.12) | 0.597 |
| Parity, live births | 707 | 0.92 (0.83-1.04) | 0.174 |
| Partner encouragement, Likert scale 1–5 | 707 | 1.60 (1.35-1.90) | <0.001 |
| ANC messages from faith leaders, yes vs no | 707 | 1.43 (0.94-2.17) | 0.092 |
| Women/community group participation, yes vs no | 707 | 0.81 (0.53-1.22) | 0.308 |
| Religious activity, ordinal; never = 0 to daily = 3 | 707 | 1.11 (0.82-1.51) | 0.501 |
| **ANC8+** | | | |
| Maternal age, years | 707 | 1.02 (0.95-1.08) | 0.619 |
| Education level, ordinal; none = 0 to higher = 3 | 707 | 1.21 (0.73-2.02) | 0.462 |
| Household asset score, 0-4 | 707 | 1.24 (0.89-1.73) | 0.210 |
| Parity, live births | 707 | 0.94 (0.75-1.18) | 0.588 |
| Partner encouragement, Likert scale 1-5 | 707 | 1.59 (1.03-2.46) | 0.037 |
| ANC messages from faith leaders, yes vs no | 707 | 1.47 (0.64-3.33) | 0.362 |
| Women/community group participation, yes vs no | 707 | 2.11 (0.84-5.26) | 0.111 |
| Religious activity, ordinal; never = 0 to daily = 3 | 707 | 0.73 (0.41-1.30) | 0.286 |

*Note: Adjusted OR, adjusted odds ratio; CI, confidence interval.*

Model diagnostics indicated acceptable performance. The timely ANC initiation model included 708 women and 282 events, with an AUC of 0.671 and no evidence of poor fit based on the Hosmer–Lemeshow test, $\chi^2 = 5.03$, df = 8, p = 0.754. The ANC4+ model included 707 women and 463 events, with an AUC of 0.689 and a non-significant Hosmer-Lemeshow test, $\chi^2 = 12.8$, df = 8, p = 0.119. The ANC8+ model included 707 women and 43 events, with an AUC of 0.702 and no evidence of poor calibration, $\chi^2 = 7.68$, df = 8, p = 0. 465. However, the interpretation of the ANC8+ model must take into account the limited number of events. Variance inflation factors were low across all models, with maximum values ranging from 1.76 to 1.77, indicating no evidence of problematic multicollinearity "Table 4".

**Table 4.** Discrimination and Calibration of Multi-variable Antenatal Care Outcome Models

| Outcome | Complete-case N | Events | AUC | VIF | Hosmer–Lemeshow $\chi^2$ | df | p-value |
|---|---|---|---|---|---|---|---|
| Timely ANC initiation | 708 | 282 | 0.671 | 1.77 | 5.03 | 8 | 0.754 |
| ANC4+ | 707 | 463 | 0.689 | 1.76 | 12.80 | 8 | 0.119 |
| ANC8+ | 707 | 43 | 0.702 | 1.76 | 7.68 | 8 | 0.465 |

*Note: df: degree of freedom.*

# Discussion

## Principal Findings

This study examined timely antenatal care (ANC) initiation, ANC4+ and ANC8+ among recently delivered host-community women in Karisimbi Health Zone, Goma, a fragile urban setting in eastern Democratic Republic of Congo (DRC). Three findings are particularly important. First, timely ANC initiation was low: Less than fifty percent of women initiated antenatal care within the first twelve week of gestation. Second, ANC4+ coverage was substantially
higher than timely initiation, whereas ANC8+ completion was rare. This pattern indicates that many women eventually enter ANC but do so late and/or do not maintain repeated contact throughout pregnancy. Third, determinants varied across the ANC continuum. Maternal age, education, household assets, parity, partner encouragement and religious activity were associated with timely initiation; age, education and partner encouragement were associated with ANC4+; and partner encouragement was the only factor retaining statistical significance for ANC8+.

The study's main contribution is to show that ANC4+ alone may substantially overestimate progress toward the current WHO ANC model in this fragile urban context [2]. Education, economic position and reproductive history appear more closely related to early entry into care, whereas sustained completion of the eight-contact pathway may depend more strongly on household or relational support [23–25]. However, the specific forms of support were not directly measured, and findings for ANC8+ should be interpreted cautiously because of the small number of women who achieved this outcome.

## ANC Initiation, ANC4+ and ANC8+ Patterns

The observed continuum 39.9% timely initiation, 65.8% ANC4+ and 6.0% ANC8+ is consistent with implementation challenges following the transition from the four-visit focused ANC model to minimum eight contact as recommended by WHO. While ANC4+ remains widely used in monitoring systems and household surveys, it no

longer represents the full standard of recommended care [1, 2, 26]. In this study, the relatively high ANC4+ coverage should therefore be interpreted as an intermediate milestone rather than evidence of adequate or optimal ANC.

The very low ANC8+ prevalence is a central finding. It suggests that the principal programmatic challenge is not only whether women make contact with ANC services, but whether they start early enough and remain engaged across pregnancy [24]. Regional findings in sub-Saharan Africa similarly indicate that completion of eight or more ANC contacts remains uncommon and is socially patterned by education, wealth, residence and parity [27, 28]. The Karisimbi estimate is consistent with this broader challenge, although it reflects a particularly low level of completion.

Several explanations are plausible. Late initiation reduces the remaining time available to complete eight contacts. Repeated attendance may also be affected by indirect costs, transport constraints, insecurity, competing household responsibilities and inconsistent communication about the eight-contact schedule [24,28]. However, these mechanisms were not directly assessed in this study and should be treated as hypotheses for future research.

These findings may also be understood in light of the distinction between contact coverage and effective coverage. This study measured the number and timing of ANC contacts, but not the content, technical quality, respectful care, continuity of records or facility readiness. ANC4+ and ANC8+ should therefore be viewed as utilization indicators rather than measures of adequate or effective care [29, 30]. Future work in Karisimbi should combine contact measures with indicators of essential ANC content and quality.

## Sociodemographic and Socioeconomic Determinants

Older maternal age was associated with timely initiation and ANC4+. This finding is consistent with evidence from Africa indicating that more and more maternal age is often related with greater ANC utilization. One possible explanation is that older women may have greater experience with pregnancy and health services or more negotiating power within households [22, 25, 26]. However, because this study was cross-sectional, the association should not be interpreted causally.

Education was one of the most consistent predictors, being associated with both timely initiation and ANC4+. This aligns with previous reviews and multi-country analyses showing that maternal education is an important determinant of ANC utilization in sub-Saharan Africa [25, 26]. Education may improve women's ability to recognize the benefits of early care, communicate with providers and navigate health services [31].

Household asset score was associated with timely initiation but not with ANC4+ or ANC8+ after adjustment. This pattern may suggest that economic position is especially important for the first step into care, when consultation costs, transport costs, opportunity costs and uncertainty about service requirements may converge. Regional studies continue to show pro-rich and pro-educated inequalities in completion of eight or more ANC contacts [27, 28].

## Role of Parity

Parity was negatively associated with timely ANC initiation but not with ANC4+ or ANC8+ in adjusted models. This is epidemiologically plausible and consistent with evidence that higher birth order is often linked with lower chances to comply with required ANC visits. Multiparous women may perceive

pregnancy as familiar, delay care until symptoms arise or face greater childcare and household responsibilities [25-28].

### Partner Encouragement and Household Support

Partner encouragement was the most consistent correlate across the ANC continuum, being associated with timely initiation, ANC4+ and ANC8+.The association between partner encouragement and ANC8+ should be interpreted with caution because only a few numbers of women succeeded eight or more contacts. Sparse events may reduce precision and increase the instability of estimates. Even so these support others evidences that male partner involvement can improve uptake of maternal care, including skilled birth attendance, institutional delivery and postnatal care [32, 33].

### Religious Activity and Community-based Exposures

Religious activity showed a negative adjusted association with timely ANC initiation, while exposure to ANC-related messages from faith leaders and participation in women's or community groups were not independently associated with ANC outcomes. These findings should be interpreted cautiously. They do not show that religion causes delayed ANC, nor do they imply that faith institutions are barriers to care [9].

The null findings for faith-leader messages and community-group participation are also informative. They suggest that passive exposure to messages may be insufficient to change ANC behavior in this context. Evidence from Ethiopia indicates that trained religious leaders can improve ANC4+ and facility delivery when their role is structured, standardized and linked to community health workers or formal referral pathways [9, 10].

### Strengths and Limitations

Taken together, the study demonstrates strong methodological rigor for a cross-sectional household survey and makes an important contribution by analyzing ANC utilization as a continuum in a fragile urban setting. However, the limitations particularly the cross-sectional design, dependance on self-reported data, absence of quality-of-care measures, and limited power for ANC8+ require cautious interpretation. Next research should prioritize longitudinal designs, integration of facility-level quality indicators, and more detailed measurements of household and community influences to strengthen causal inference and program relevance.

## Conclusion

This study showed locally grounded evidence on the ANC continuum in a fragile urban setting of eastern DRC. Timely ANC initiation was suboptimal, ANC4+ was relatively common, and ANC8+ completion was rare, indicating that ANC4+ alone substantially overstates progress toward the current WHO ANC model. Education, assets, age and parity were associated mainly with early entry into care, whereas partner encouragement was the most consistent correlate across the continuum, although the ANC8+ finding requires cautious interpretation because of sparse events. Community and faith-based exposures, as measured here, were not independently associated with ANC outcomes.

Programs in Karisimbi should therefore combine early pregnancy identification, equity-oriented access strategies, respectful household engagement, structured community linkages and health-system strengthening to support earlier, more continuous and higher-quality ANC

## Conflict of Interest

Non-competing interest exists.

## Ethical Approval

The study was reviewed and approved by the Ethics Review Board of the University of Goma in Goma, where the research was conducted (Approval No. 10/ESAPU/UNIGOM).

## Author Contributions

David Munganga Kaseke conceptualized the study, coordinated collection, interpretation and prepared the manuscript for journal submission under guidance of Jerome Mastaki Kambale and Didier Mukeba Tchalala.

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## Data Availability

The data utilized in this research may be granted upon request, albeit anonymized to safeguard participant privacy.

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# Clinical Profile and Predictors of Childhood Overweight Following In-Utero Exposure to Gestational Diabetes Mellitus: A Retrospective Cohort Study in Guyana

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***Abstract*** *Children exposed to gestational diabetes mellitus (GDM) in utero are at increased long-term risk of obesity and dysglycaemia, yet Caribbean data remain scarce. This retrospective cohort analysis characterised the clinical profile and examined predictors of abnormal body mass index (BMI) among GDM-exposed children in Guyana. Perinatal data were extracted from the records of 33 mothers diagnosed with GDM during the index pregnancy (January–June 2017); informed consent was then obtained and structured maternal telephone interviews ascertained current child parameters. Anthropometric status was classified using the United States Centers for Disease Control and Prevention (CDC) BMI-for-age reference. Associations with overweight/obesity were assessed using Fisher's exact test (with unadjusted odds ratios [OR] and 95% confidence intervals [CI]), the Mann–Whitney U test and the Spearman rank correlation. Overall, 13 children (39.4%, 95% CI 24.7–56.3) were overweight or obese and 5 (15.2%) were obese, while 8 (24.2%) had been macrosomic at birth. No factor was a statistically significant independent predictor of overweight/obesity. The strongest, non-significant signals were a higher number of daily meals (OR 5.62, 95% CI 0.89–35.39; $p = 0.084$) and lower birth weight (OR 3.43, 95% CI 0.73–16.09; $p = 0.139$); girls had a higher median BMI than boys (17.9 vs 16.6 kg/m²; $p = 0.169$). Birth weight was not positively correlated with current BMI ($\rho = -0.18$; $p = 0.33$). This exploratory, underpowered analysis supports routine longitudinal surveillance of GDM-exposed children and adequately powered comparative studies to inform maternal and child health policy in Guyana.*

***Keywords*** *Body Mass Index, Childhood Obesity, Developmental Origins of Health and Disease, Guyana, Gestational Diabetes Mellitus, Retrospective Cohort.*

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## Introduction

Gestational diabetes mellitus (GDM), defined as hyperglycaemia first recognised during pregnancy, is among the most common medical complications of pregnancy, and its frequency is rising worldwide alongside obesity and type 2 diabetes [4, 5]. The landmark Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study established a continuous association between maternal glycaemia and adverse perinatal outcomes [2, 20], informing the diagnostic thresholds subsequently recommended by the International Association of Diabetes and Pregnancy Study Groups (IADPSG) and the World Health Organization (WHO) [1, 3].

Beyond the perinatal period, the developmental origins of health and disease (DOHaD) framework holds that the intrauterine environment programmes long-term metabolic risk in the offspring [6, 24]. Considerable evidence links in-utero exposure to GDM with later childhood overweight, obesity, adiposity and impaired glucose metabolism [7-10], adding to the global burden of childhood obesity [23]. Studies of discordant sibships and longitudinal cohorts such as EPOCH and the HAPO Follow-up Study (HAPO FUS) support an at-least-partly intrauterine contribution that is not fully explained by maternal body mass index (BMI) [11-14]. Mothers with GDM also carry a high risk of progression to type 2 diabetes, and their offspring show elevated rates of dysglycaemia, compounding the intergenerational cycle of cardiometabolic disease [15, 22].

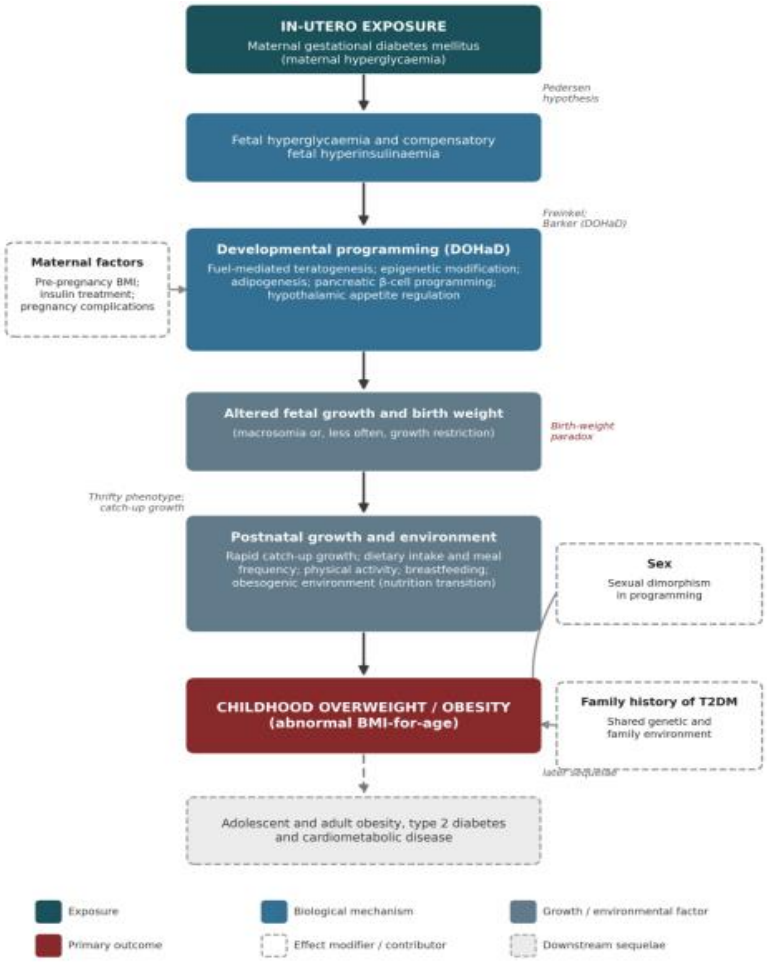


**Figure 1.** Conceptual Framework Illustrating the Hypothesized Pathways Linking In-utero Exposure to Gestational Diabetes Mellitus and Childhood Overweight/Obesity

Most evidence, however, derives from high-income or large multinational cohorts; data describing GDM-exposed children in the Caribbean, and in Guyana specifically, are sparse. Characterising the clinical profile of these children and identifying early, potentially modifiable predictors of abnormal weight status is a prerequisite for targeted follow-up and prevention [16, 21]. The present study therefore aimed to (i) describe the clinical, perinatal and lifestyle profile of a cohort of GDM-exposed children in Guyana, and (ii) examine perinatal, lifestyle, maternal and family-history predictors of abnormal (overweight/obese) BMI category. A conceptual framework summarising the hypothesised pathways is shown in Figure 1.

To our knowledge, this is the first retrospective cohort study from Guyana and one of the very few studies from the Caribbean evaluating childhood anthropometric outcomes following in-utero exposure to gestational diabetes mellitus. The findings provide locally generated evidence to inform long-term follow-up strategies for mothers with GDM and their children.

## Materials and Methods

### Study Design and Setting

This was a retrospective cohort analysis conducted within the public health service in Guyana, with participants managed at the Georgetown Public Hospital Corporation (GPHC). The cohort was assembled in two phases. In the first phase, between January and June 2017, data were extracted from the records of mothers diagnosed with GDM during the index pregnancy, from which 33 GDM mother–child pairs were selected. In the second phase, informed consent was subsequently obtained from the parents (mothers) of the index children, and structured telephone interviews were then conducted with the mothers to ascertain key parameters concerning the child, including current growth and anthropometry, infant feeding, diet, lifestyle, physical activity, sleep and family history. The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidance for cohort studies.

### Study Population and Sampling

The source population comprised all women who gave birth at the GPHC between 1 January and 30 June 2017. Eligible participants were those with a diagnosis of GDM confirmed in the hospital records of the index pregnancy, and the study population therefore comprised the children born to these mothers. GDM had been diagnosed in accordance with the GPHC Guidelines for the Diagnosis and Treatment of Diabetes in Pregnancy (updated November 2013): a fasting blood glucose ≥ 92 mg/dL (5.1 mmol/L) or, on a 2-hour oral glucose tolerance test, any one of a fasting value ≥ 92 mg/dL (5.1 mmol/L), a 1-hour value ≥ 180 mg/dL (10.0 mmol/L), or a 2-hour value ≥ 155 mg/dL (8.6 mmol/L) [28]. Of the 42 women with GDM who met the inclusion criteria during this period, complete records permitting full case extraction were available for 33 (33/42; 78.6%), and these mother–child pairs formed the study cohort; sampling was therefore by total (consecutive) enumeration of eligible records rather than probability sampling.

### Inclusion and Exclusion Criteria

Children were eligible for inclusion if their mother had a documented diagnosis of GDM in the index pregnancy during January–June 2017, if birth and perinatal records were available, and if the mother provided informed consent to participate in the follow-up telephone interview. Children were excluded if the mother had pre-gestational (type 1 or type 2) diabetes diagnosed before the index pregnancy, if core birth records were missing, or if the mother could not be contacted or declined to provide consent. The resulting participant flow is summarised in Figure 2.

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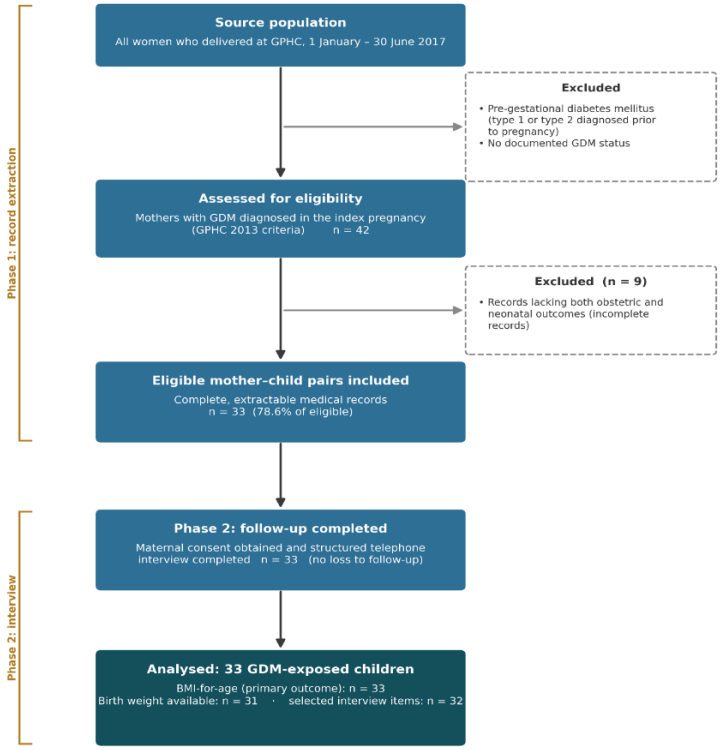


**Figure 2.** Flow of Participants through the Study, from the Source Population to the Analysed Cohort

## Data Collection and Variables

Perinatal and birth variables (birth weight, gestational age, five-minute Apgar score and complications at birth) were abstracted from maternal and child clinical records during the 2017 extraction phase. Current child variables were obtained through the structured maternal telephone interviews and supplemented by available clinic measurements; these comprised anthropometry (weight and height), infant-feeding history (ever breastfed, exclusive and total breastfeeding duration, age at introduction of formula and solids), dietary patterns (meals and snacks per day, and frequency of sugary drinks and other foods), physical activity, screen time, sleep, and family history of diabetes and hypertension. Maternal variables (GDM treatment, pregnancy complications and height) were recorded from the clinical records. Current weight and height were, for most children, reported by the mother during the telephone interview rather than measured directly by the study team, with clinic measurements used where available.

## Variable Definitions

The exposure was in-utero GDM (all participants exposed). The primary outcome was an abnormal high BMI category (overweight or obesity) at assessment. BMI (kg/m²) was calculated from measured weight and height and classified for age and sex using the CDC BMI-for-age reference: overweight, 85th–<95th percentile; obesity, ≥95th percentile; and severe obesity, ≥120% of the 95th percentile [17, 18]. Macrosomia was defined as birth weight ≥4000 g, low birth weight as <2500 g, and preterm birth as delivery before 37 completed weeks. Exclusive breastfeeding referred to breast milk only, without other liquids or solids. Family history was defined as a first-degree relative with the condition.

## Statistical Analysis

Continuous variables were screened for normality (Shapiro–Wilk test) and summarised as mean ± standard deviation (SD) or median

(interquartile range, IQR) as appropriate; categorical variables are presented as counts and percentages. The 95% CI for the prevalence of overweight/obesity was estimated using the Wilson score method. Associations between candidate exposures and overweight/obesity were examined using Fisher's exact test for categorical variables, with unadjusted odds ratios (OR) and 95% CIs (Haldane–Anscombe correction where a zero cell was present), and the Mann–Whitney U test for continuous variables. Monotonic associations between continuous exposures and current BMI were assessed using the Spearman rank correlation coefficient (ρ). Given the small sample and limited number of outcome events, multivariable modelling was not undertaken; analyses were unadjusted, exploratory and not corrected for multiple comparisons, and a two-sided p-value $< 0.05$ was considered statistically significant. Analyses were performed in Python (version 3.12; pandas, SciPy and statsmodels packages). Missing data were handled by available-case analysis, with each estimate based on all participants having non-missing data for the relevant variables and the denominator reported throughout; no imputation was undertaken. The parents accompanied the children to the nearest health center where anthropometric measurements were performed by the clinical staff of the corresponding health facility. The anthropometric measurements were then reported via telephone interview in a follow-up interview to specifically collect this data.

## Results

### Cohort and Participant Flow

Thirty-three GDM-exposed children were included. The mean age was 9.2 ± 0.1 years, and 18 (54.5%) were boys. The cohort was predominantly of African (20, 60.6%) and East Indian (7, 21.2%) ethnicity. Data on sex were complete for all 33 children; a small number of interview items (notably screen time) were incomplete, and denominators are reported for each variable. The flow of participants through the study is shown in Figure 2, and demographic and birth characteristics in Table 1.

**Table 1.** Demographic and Birth Characteristics of the Cohort (N = 33)

| **Characteristic** | **Value** |
|---|---|
| Child age, years — mean ± SD | 9.16 ± 0.13 |
| **Sex, n (%)** | |
| Male | 18 (54.5) |
| Female | 15 (45.5) |
| **Ethnicity, n (%)** | |
| East Indian | 7 (21.2) |
| African | 20 (60.6) |
| Mixed | 1 (3.0) |
| Amerindian | 1 (3.0) |
| Other | 4 (12.1) |
| Birth weight, g — mean ± SD | 3385.0 ± 678.84 |
| Macrosomia (≥4000 g), n (%) | 8 (24.2) |
| Low birth weight (<2500 g), n (%) | 2 (6.1) |
| Gestational age, weeks — median (IQR) | 38.86 (37.64–39.29) |
| Preterm (<37 weeks), n (%) | 6 (18.2) |
| 5-minute APGAR — median (IQR) | 10.0 (10.0–10.0) |

## Clinical Profile: Anthropometric Status, BMI Classification and Percentiles

At a median age of nine years, the median BMI was 17.1 (IQR 15.4–20.1) kg/m² and the median BMI-for-age percentile was 67.0 (IQR 31.0–90.0). Sixteen children (48.5%) were of healthy weight and four (12.1%) were underweight. In total, 13 children (39.4%, 95% CI 24.7–56.3) were overweight or obese (8 [24.2%] overweight, 3 [9.1%] with obesity and 2 [6.1%] with severe obesity), and 5 (15.2%, 95% CI 6.7–30.9) met the criterion for obesity. At birth, 8 children (24.2%) had been macrosomic. The distribution of BMI categories is shown in Figure 3, the distribution of birth weight in Figure 4, and full anthropometric findings, including percentiles, in Table 2.

**Table 2.** Anthropometric Status, BMI Classification and Percentiles (N = 33)

| **Characteristic** | **Value** |
|---|---|
| Current weight, kg — median (IQR) | 30.0 (27.3–35.7) |
| Current height, cm — mean ± SD | 131.65 ± 6.21 |
| BMI, kg/m² — median (IQR) | 17.1 (15.4–20.1) |
| BMI-for-age percentile — median (IQR) | 67.0 (31.0–90.0) |
| **BMI-for-age category, n (%)** | |
| Underweight | 4 (12.1) |
| Healthy weight | 16 (48.5) |
| Overweight | 8 (24.2) |
| Obesity | 3 (9.1) |
| Severe obesity | 2 (6.1) |
| Overweight or obese, n (% [95% CI]) | 13 (39.4 [24.7–56.3]) |
| Obese (incl. severe), n (% [95% CI]) | 5 (15.2 [6.7–30.9]) |

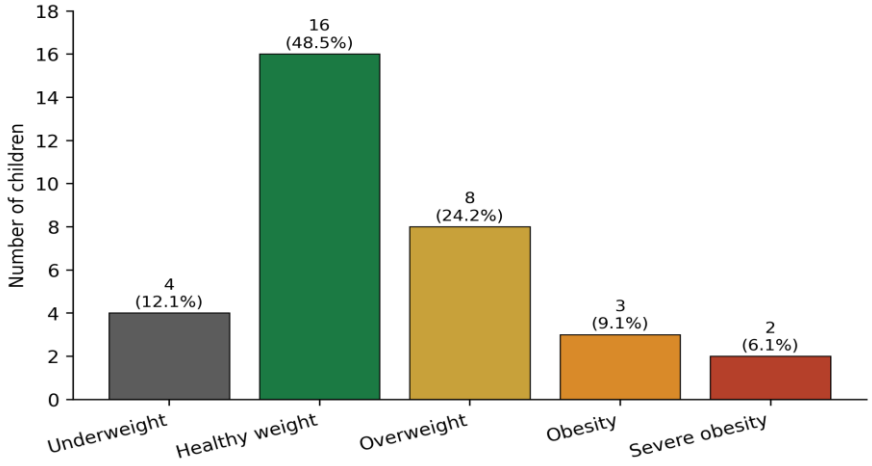


**Figure 3.** Distribution of BMI-for-Age Categories among the 33 GDM-exposed Children

## Clinical Profile: Breastfeeding, Infant Feeding, Diet, Lifestyle, Physical Activity, Sleep and Maternal/Family Characteristics

Almost all children (32, 97.0%) had been breastfed, for a median total duration of 15 (IQR 12–19) months and a median exclusive duration of 5 (IQR 3–6) months. Reported diet and activity patterns were broadly favourable (median 3 meals/day, high reported physical activity, median sleep 10 hours/night, median screen time 4 hours/day). Nearly all mothers had received insulin during the index pregnancy (32, 97.0%), 16 (48.5%) had

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documented gestational or chronic hypertension, and a family history of type 2 diabetes was reported for 17 children (51.5%). Feeding, lifestyle, maternal and family characteristics are presented in Tables 3 and 4.

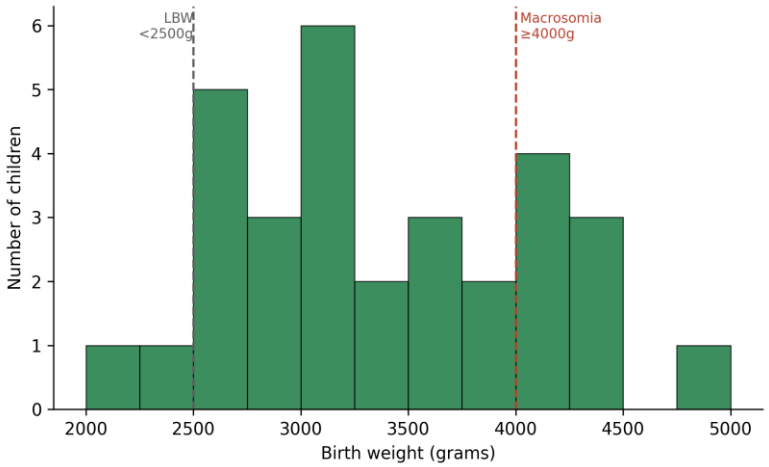


**Figure 4.** Distribution of Birth Weight (n = 31); Dashed Lines Mark the Low-birth-Weight (<2,500 g) and Macrosomia (≥4,000 g) Thresholds

**Table 3.** Breastfeeding, Infant Feeding, Diet, Lifestyle, Physical Activity and Sleep (N = 33)

| Characteristic | Value |
|---|---|
| Ever breastfed, n (%) | 32 (97.0) |
| Exclusive breastfeeding, months — median (IQR) | 5.0 (3.0–6.0) |
| Total breastfeeding, months — median (IQR) | 15.0 (12.0–19.0) |
| Age formula introduced, months — median (IQR) | 5.0 (3.0–6.0) |
| Age solids introduced, months — median (IQR) | 7.0 (7.0–8.0) |
| Meals per day — median (IQR) | 3.0 (3.0–3.0) |
| Snacks per day — median (IQR) | 3.5 (3.0–4.0) |
| Eats breakfast daily, n (%) | 32 (97.0) |
| Daily fresh fruit, n (%) | 29 (87.9) |
| Daily fresh vegetables, n (%) | 19 (57.6) |
| Sugary drinks daily, n (%) | 11 (33.3) |
| Fast food weekly+, n (%) | 13 (39.4) |
| Sweets weekly+, n (%) | 6 (18.2) |
| Physical activity, days/week — median (IQR) | 7.0 (5.75–7.0) |
| Physical activity, hours/day — median (IQR) | 3.5 (3.0–4.0) |
| Screen time, hours/day — median (IQR) | 4.0 (3.0–4.12) |
| Sleep, hours/night — median (IQR) | 10.0 (9.5–10.0) |

**Table 4.** Maternal and Family Characteristics (N = 33)

| Characteristic | Value |
|---|---|
| **Maternal GDM treatment, n (%)** | |
| Insulin (±other) | 32 (97.0) |
| Metformin only | 1 (3.0) |
| Insulin exposure in utero, n (%) | 32 (97.0) |
| Maternal height, cm — mean ± SD | 160.08 ± 7.17 |

| | |
|---|---|
| Any maternal pregnancy complication, n (%) | 28 (84.8) |
| Gestational/chronic hypertension, n (%) | 16 (48.5) |
| Family history of type 2 diabetes, n (%) | 17 (51.5) |
| Family history of hypertension, n (%) | 10 (30.3) |
| Mother's education ≥ secondary, n (%) | 31 (93.9) |

## Bivariate Associations and Predictors of Overweight/Obesity

Bivariate associations between candidate exposures and overweight/obesity are summarised in Table 5, and Spearman correlations between continuous exposures and current BMI in Table 6. No exposure was significantly associated with overweight/obesity. The unadjusted odds ratios with 95% confidence intervals for the categorical predictors are presented in Table 7 and displayed in Figure 6. All confidence intervals were wide and included the null, consistent with limited statistical power. The strongest signals, none reaching significance, were a higher number of daily meals (≥4 meals/day: OR 5.62, 95% CI 0.89–35.39; p = 0.084) and lower birth weight (<3000 g: OR 3.43, 95% CI 0.73–16.09; p = 0.139), each associated with higher odds of overweight/obesity. The presence of any maternal pregnancy complication was associated with lower odds (OR 0.12, 95% CI 0.01–1.22; p = 0.066). Female sex and a family history of type 2 diabetes were each associated with approximately two-fold higher odds, again non-significant.

**Table 5.** Bivariate Associations between Candidate Exposures and Overweight/Obesity (Overweight/Obese vs not)

| Exposure | Test | p-value |
|---|---|---|
| Sex (female vs male) | Fisher exact | 0.493 |
| Macrosomia (yes vs no) | Fisher exact | 0.431 |
| Preterm (yes vs no) | Fisher exact | 0.364 |
| Ever breastfed | Fisher exact | 1.000 |
| Family history T2DM | Fisher exact | 0.481 |
| Family history HTN | Fisher exact | 0.461 |
| Maternal hypertension | Fisher exact | 0.481 |
| Any maternal complication | Fisher exact | 0.066 |
| Participates in organized sport | Fisher exact | 1.000 |
| Birth weight † | Mann–Whitney U | 0.060 |
| Gestational age † | Mann–Whitney U | 0.845 |
| Exclusive breastfeeding † | Mann–Whitney U | 0.635 |
| Total breastfeeding † | Mann–Whitney U | 0.949 |
| Screen time † | Mann–Whitney U | 0.238 |
| Physical activity (h/day) † | Mann–Whitney U | 0.284 |
| Sleep duration † | Mann–Whitney U | 0.162 |
| Maternal height † | Mann–Whitney U | 0.205 |

*p-values from Fisher's exact test (categorical exposures) or the Mann–Whitney U test (continuous exposures). Directional effect sizes (unadjusted odds ratios with 95% confidence intervals) for the categorical predictors are presented in Table 7.*

**Table 6.** Spearman Rank Correlations between Continuous Exposures and Current BMI

| Exposure | n | Spearman ρ | p-value |
|---|---|---|---|
| Birth weight (g) | 31 | -0.18 | 0.329 |
| Gestational age (weeks) | 32 | 0.12 | 0.518 |
| Exclusive breastfeeding (months) | 29 | -0.14 | 0.455 |
| Total breastfeeding (months) | 30 | -0.24 | 0.208 |
| Meals per day | 33 | 0.30 | 0.085 |
| Snacks per day | 30 | 0.30 | 0.106 |
| Physical activity (days/week) | 32 | 0.16 | 0.389 |
| Screen time (hours/day) | 32 | -0.20 | 0.260 |
| Sleep (hours/night) | 32 | 0.14 | 0.459 |
| Maternal height (cm) | 28 | -0.20 | 0.315 |

**Table 7.** Unadjusted Associations between Candidate Predictors and Overweight/Obesity (n = 33; 13 Events)

| Predictor (index vs reference) | Index, n/N (%) | Reference, n/N (%) | OR (95% CI) | p |
|---|---|---|---|---|
| Female sex | 7/15 (46.7%) | 6/18 (33.3%) | 1.75 (0.43–7.17) | 0.493 |
| Macrosomia at birth (≥4000 g) | 2/8 (25%) | 11/25 (44%) | 0.42 (0.07–2.53) | 0.431 |
| Birth weight <3000 g | 6/10 (60%) | 7/23 (30.4%) | 3.43 (0.73–16.09) | 0.139 |
| Preterm birth (<37 wks) | 1/6 (16.7%) | 12/27 (44.4%) | 0.25 (0.03–2.44) | 0.364 |
| Not breastfed | 0/1 (0%) | 13/32 (40.6%) | 0.48 (0.02–12.73) | 1 |
| Family history of type 2 diabetes | 8/17 (47.1%) | 5/16 (31.2%) | 1.96 (0.47–8.11) | 0.481 |
| Family history of hypertension | 5/10 (50%) | 8/23 (34.8%) | 1.88 (0.42–8.47) | 0.461 |
| Maternal hypertension in pregnancy | 5/16 (31.2%) | 8/17 (47.1%) | 0.51 (0.12–2.12) | 0.481 |
| Any maternal pregnancy complication | 9/28 (32.1%) | 4/5 (80%) | 0.12 (0.01–1.22) | 0.066 |
| Maternal insulin treatment | 13/32 (40.6%) | 0/1 (0%) | 2.08 (0.08–54.92) | 1 |
| No participation in organized sport | 0/1 (0%) | 13/32 (40.6%) | 0.48 (0.02–12.73) | 1 |
| Daily sugary-drink consumption | 2/11 (18.2%) | 11/22 (50%) | 0.22 (0.04–1.27) | 0.132 |
| Screen time ≥4 h/day | 7/19 (36.8%) | 6/14 (42.9%) | 0.78 (0.19–3.19) | 1 |
| ≥4 meals/day | 5/7 (71.4%) | 8/26 (30.8%) | 5.62 (0.89–35.39) | 0.084 |

*OR, odds ratio; CI, confidence interval. Odds ratios are unadjusted; the Haldane–Anscombe correction (+0.5) was applied where a zero cell was present. p-values from Fisher's exact test.*

The comparison of continuous characteristics by weight status was consistent with these findings (Table 8). Children who were overweight or obese had a lower median birth weight than their non-overweight peers (3,120 vs 3,550 g; p = 0.060) and a marginally higher number of daily meals (p = 0.052). Birth weight was not positively correlated with current BMI (ρ = −0.18; p = 0.33; Figure 5). The non-significant inverse association between daily sugary-drink consumption and overweight (OR 0.22) is most plausibly attributable to small-sample noise or reverse causation and is not interpreted further.

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**Table 8.** Continuous Characteristics by Weight Status, Median (IQR)

| Variable | Overweight/obese (n≈13) | Not overweight (n≈20) | p |
|---|---|---|---|
| Birth weight (g) | 3120 (2700–3200) | 3550 (3095–4105) | 0.060 |
| Gestational age (weeks) | 38.9 (38.3–39.3) | 38.7 (36.8–39.3) | 0.845 |
| Meals per day | 3 (3–4) | 3 (3–3) | 0.052 |
| Total breastfeeding (months) | 15 (14–18) | 15 (12–23) | 0.949 |
| Sleep (hours/night) | 10.0 (9.7–10.0) | 10.0 (9.5–10.0) | 0.162 |
| Maternal height (cm) | 159 (156–163) | 164 (155–168) | 0.205 |

*p-values from the Mann–Whitney U test. Group sizes vary by item owing to missing data.*

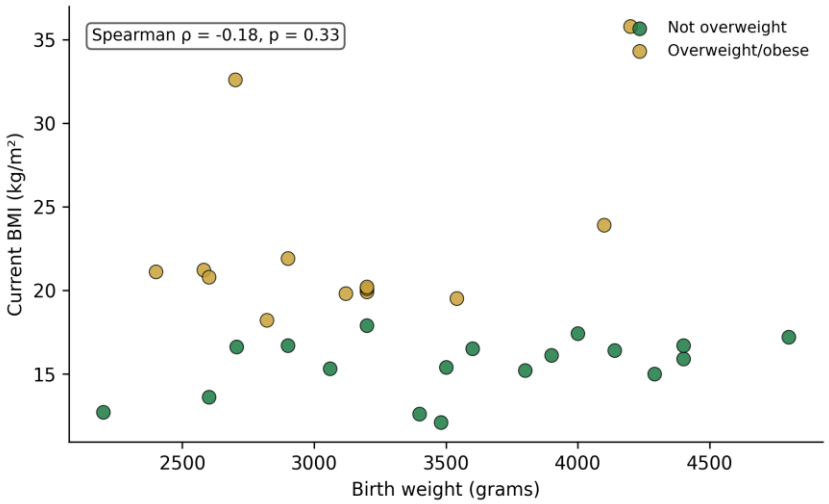


**Figure 5.** Birth Weight Versus Current BMI (n = 31). The Spearman Correlation was Weak and Non-significant

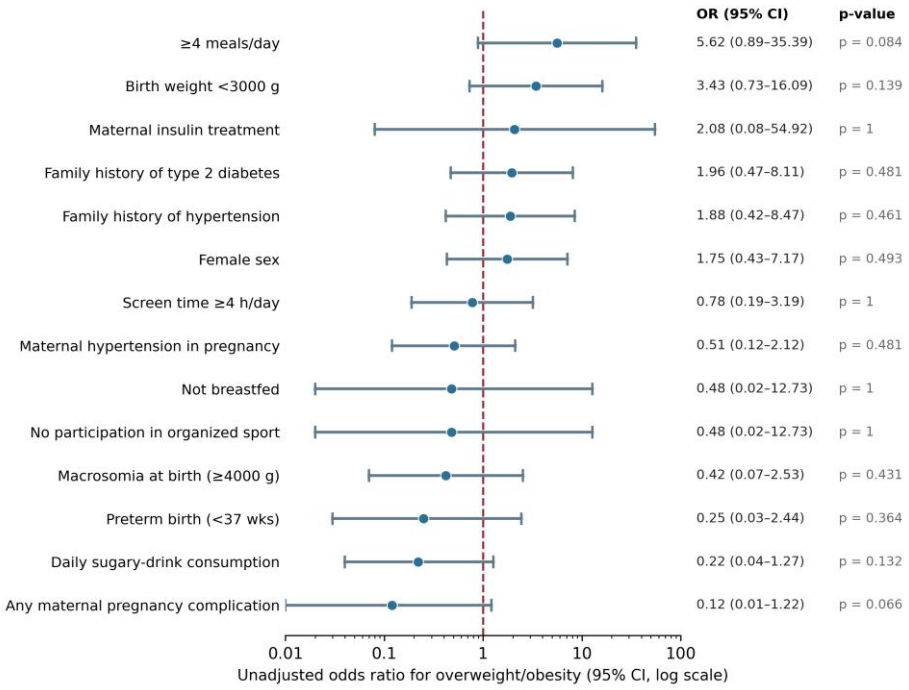


**Figure 6.** Forest Plot of Unadjusted Odds Ratios (95% Confidence Intervals) for Overweight/Obesity by Candidate Predictor; the Vertical Line Marks the Null (OR = 1)

### Sex-stratified Anthropometric Outcomes

Anthropometric outcomes by sex are presented in Table 9 and Figure 7. Girls had a higher median BMI (17.9 vs 16.6 kg/m²; p = 0.169) and BMI-for-age percentile (75.0th vs 57.0th; p = 0.205) than boys, and a higher prevalence of overweight/obesity (7/15, 46.7% vs 6/18, 33.3%; OR 1.75, 95% CI 0.43–7.17; p = 0.49). Birth weight did not differ by sex (median 3,340 vs 3,200 g; p = 0.74). None of these sex differences reached statistical significance, but the direction — a tendency towards greater adiposity among girls — is consistent with reports of sex-specific intrauterine programming considered in the Discussion.

**Table 9.** Sex-Stratified Anthropometric and Birth Outcomes

| Measure | Boys (n = 18) | Girls (n = 15) | p |
|---|---|---|---|
| Current BMI (kg/m²), median (IQR) | 16.6 (15.3–19.4) | 17.9 (16.5–21.6) | 0.169 |
| BMI-for-age percentile, median (IQR) | 57.0 (27.3–87.5) | 75.0 (53.0–94.0) | 0.205 |
| Overweight/obese, n (%) | 6 (33.3) | 7 (46.7) | 0.493 |
| Macrosomia at birth, n (%) | 3 (16.7) | 5 (33.3) | — |
| Birth weight (g), median (IQR) | 3200 (3060–3800) | 3340 (2701–4075) | 0.736 |

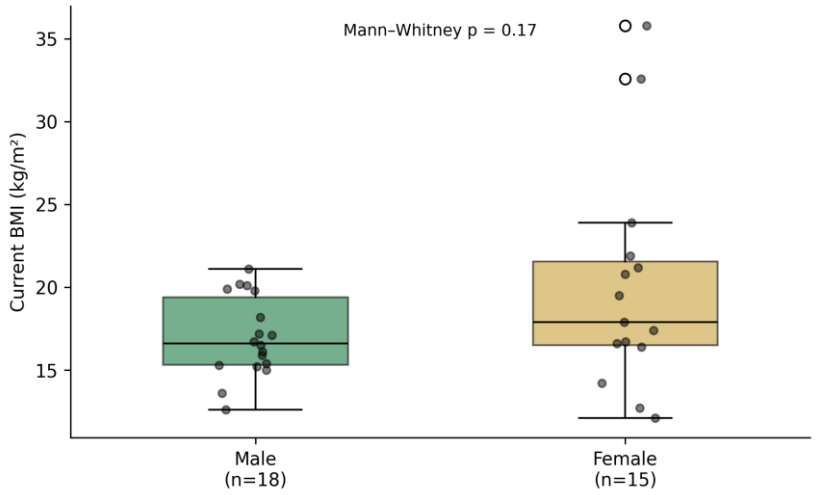


**Figure 7.** Current BMI by Sex. Boxes show Median and Interquartile Range; Individual Values are Overlaid

## Discussion

In this retrospective cohort of GDM-exposed children in Guyana, two in five children (39.4%) were already overweight or obese by a median age of nine years, and one in seven (15.2%) met the criterion for obesity, including 6.1% with severe obesity. Nearly a quarter (24.2%) had been macrosomic at birth. Although no factor emerged as a statistically significant independent predictor of abnormal BMI — unsurprising given the small sample and wide confidence intervals — the most consistent signals pointed to a higher number of daily meals and, paradoxically, lower birth weight as correlates of later overweight, with girls tending towards greater adiposity than boys. Overall, the cohort already carried a considerable cardiometabolic burden in middle childhood. Because the sample was small, these results are better understood as a coherent clinical pattern than as precise risk estimates, and they are consistent with the recognised effects of in-utero hyperglycaemic exposure.

The 39.4% prevalence of overweight or obesity observed here is consistent with, and lies towards the upper end of, the evidence linking in-utero GDM exposure to later childhood adiposity. The systematic review and

meta-analysis by Philipps and colleagues reported that offspring of diabetic pregnancies had a higher mean BMI z-score in childhood, with the association attenuating but persisting after adjustment for maternal BMI [7], and the systematic review by Kim and colleagues similarly concluded that GDM exposure is associated with increased odds of offspring overweight and obesity [8]. Prospective data strengthen this picture: in the HAPO Follow-up Study, higher maternal glycaemia during pregnancy predicted greater childhood adiposity and impaired glucose metabolism in a continuous, threshold-free manner even among mothers who would not have met older diagnostic criteria [13, 14], while Boney and colleagues showed that the combination of large-for-gestational-age birth and maternal GDM markedly increased the risk of childhood metabolic syndrome [9].

Several factors may explain why the prevalence in this cohort sits at the higher end of published estimates. First, the cohort is uniformly exposed and lacks an internal unexposed comparator, so the figure reflects absolute burden rather than excess risk. Second, Guyana, like much of the Caribbean and the wider Latin American region, is undergoing a rapid nutrition transition in which an obesogenic post-natal environment is superimposed on intrauterine metabolic programming, a convergence that can amplify offspring adiposity beyond that seen in higher-income settings [4, 23]. Third, the modest sample renders the point estimate imprecise. The co-existence of overweight or obesity (39.4%) with underweight (12.1%) in the same small cohort mirrors the double burden of malnutrition increasingly described in transitional economies, and suggests that the high adiposity prevalence cannot be attributed to generalised over-nutrition alone.

These findings are consistent with the wider regional picture. A systematic review of childhood and adolescent overweight and obesity in Latin America and the Caribbean reported combined overweight and obesity prevalences of 18.9% to 36.9% among school-aged children [29], and regional surveillance has documented a sustained rise in childhood overweight across the region over the past two decades [30]. The 39.4% prevalence in the present GDM-exposed cohort lies at or above the upper limit of these general-population estimates, consistent with an additional contribution from in-utero hyperglycaemic exposure superimposed on an already high regional background risk. Direct comparison is limited, however, because the regional figures derive from general paediatric populations rather than GDM-exposed children, and because the present sample is small.

The observed phenotype is biologically consistent with long-standing models of diabetic pregnancy. The Pedersen hypothesis proposed that maternal hyperglycaemia drives fetal hyperglycaemia and compensatory fetal hyperinsulinaemia, promoting excessive fetal growth and fat accretion [26]. Freinkel subsequently broadened this to the concept of fuel-mediated teratogenesis, in which not only glucose but the entire mixture of maternal fuels reaching the fetus during sensitive developmental windows exerts durable, anthropometric and metabolic consequences on the offspring [25]. Fetal hyperinsulinaemia is both a growth signal in utero and a plausible programming stimulus for later adipogenesis, altered appetite regulation and impaired β-cell reserve, providing a mechanistic bridge between intrauterine exposure and the elevated childhood adiposity and dysglycaemia documented in exposed cohorts [13, 14].

These proximal endocrine effects are embedded within the broader developmental origins of health and disease (DOHaD) framework, which holds that environmental exposures during critical periods of plasticity permanently shaped tissue structure, metabolic set-points and disease susceptibility [6]. Candidate molecular substrates include epigenetic modification of genes governing

energy balance, insulin signalling and adipocyte differentiation, as well as the programming of hypothalamic appetite circuits. Evidence from discordant-sibship designs, in which siblings born before and after the mother developed diabetes are compared, supports a specifically intrauterine contribution that is not wholly explained by shared genes or family environment [11]. The near-universal exposure of the present cohort to maternal insulin therapy (97.0%) indicates clinically significant maternal hyperglycaemia, consistent with a meaningful fuel-mediated programming stimulus, even though treatment itself cannot be disentangled from disease severity in these data.

A counter-intuitive finding was the absence of a positive birth-weight–current-BMI association ($\rho = -0.18$; $p = 0.33$) and the signal that lower birth weight, rather than macrosomia, accompanied later overweight (birth weight <3000 g: OR 3.43, 95% CI 0.73–16.09). Although GDM is classically linked to macrosomia, the relationship between birth weight and later adiposity across populations is frequently U-shaped, with risk elevated at both extremes of the birth-weight distribution. The thrifty phenotype hypothesis offers one explanation: fetal nutritional constraint programmes a metabolically thrifty physiology that becomes maladaptive, and obesogenic, when followed by post-natal nutritional abundance [24]. Often it is the post-natal growth trajectory, rather than birth size, that determines later adiposity: rapid infant catch-up growth has been prospectively associated with childhood obesity [27], and longitudinal modelling in the EPOCH study showed that diabetes-exposed offspring diverge in BMI trajectory during childhood rather than at birth [12].

In this light, the present cohort's pattern — weak or inverse birth-weight associations alongside high mid-childhood adiposity — is compatible with a scenario in which the principal driver of overweight is accelerated post-natal weight gain superimposed on intrauterine programming, rather than birth size per se. This interpretation is necessarily tentative given the wide confidence intervals, but it shows why birth weight alone is an inadequate screening criterion for later metabolic risk in GDM-exposed children and why growth-trajectory surveillance is preferable to single time-point anthropometry.

Macrosomia at birth was not associated with later overweight or obesity in this cohort. Although GDM increases the risk of macrosomia, and macrosomia is itself a recognised marker of later adiposity, the relationship between the two is neither necessary nor direct. Several factors may explain the absent association here. The number of macrosomic children was small (n = 8), giving very limited power to detect a difference; maternal insulin treatment was near-universal (97%) and may have attenuated fetal overgrowth, weakening any macrosomia signal; and, as noted, later adiposity in programmed children is often driven more by post-natal growth trajectory than by birth size. The finding that lower, rather than higher, birth weight accompanied later overweight in these data is consistent with this post-natal, catch-up-growth interpretation.

Among modifiable post-natal factors, a higher number of daily meals showed the strongest (though non-significant) association with overweight/obesity (≥4 meals/day: OR 5.62, 95% CI 0.89–35.39) and the largest positive correlation with BMI ($\rho = 0.31$), consistent with the recognised contribution of the post-natal dietary environment to weight trajectories in programmed children [9, 19]. The counter-intuitive inverse association between daily sugary-drink consumption and overweight is almost certainly an artefact of the small sample or of reverse causation — families of heavier children restricting sugary drinks — and is not interpreted further. The tendency towards greater adiposity in girls (median BMI 17.9 vs 16.6 kg/m²; overweight/obesity 46.7%

vs 33.3%) aligns with reports of sexually dimorphic intrauterine programming, in which female offspring of diabetic pregnancies may be more susceptible to adiposity-related outcomes [7]; however, the analysis was underpowered to confirm a sex difference and this observation should be regarded as hypothesis-generating. Finally, a family history of type 2 diabetes was present for over half the cohort (51.5%), reflecting the shared genetic and environmental milieu that compounds intrauterine programming, while the paradoxical inverse association between maternal pregnancy complications and child overweight (OR 0.12) rests on very small cell counts and should not be over-interpreted.

The central public-health message is that a large proportion of GDM-exposed children in this setting already carry an abnormally high BMI by middle childhood, identifying them as a concrete, identifiable group for early intervention. This reinforces the case for structured, long-term anthropometric and metabolic surveillance of GDM-exposed children, ideally beginning in infancy to capture growth trajectory rather than relying on birth weight or a single later measurement. Such follow-up is most efficient when coupled with maternal postpartum care, given that women with GDM carry a high lifetime risk of progression to type 2 diabetes [22] and that their offspring show elevated dysglycaemia risk [15], a connected intergenerational pathway that one coordinated screening programme could address. Embedding these activities within a standardised national GDM registry would enable prospective ascertainment, linkage of mother and child records, and equitable follow-up across Guyana's regionalised health system, consistent with international guidance on the continuum of diabetes-in-pregnancy care [16, 21].

From an implementation perspective, several concrete steps follow for Guyana and comparable settings. Long-term follow-up of GDM-exposed children could be integrated into existing maternal diabetes and antenatal services, so that mother and child are reviewed within a single care pathway rather than separately. Routine measurement of BMI-for-age at child-health and immunisation visits would allow early identification of children moving onto an obesogenic trajectory. Lifestyle and nutritional counselling begun during the index pregnancy and continued post-partum could address both maternal progression to type 2 diabetes and the child's early growth environment. A standardised national GDM registry would link maternal and child records, support recall for follow-up, and generate the prospective data needed to quantify risk locally. These activities align with existing non-communicable disease (NCD) prevention programmes, and embedding GDM-offspring follow-up within the national NCD framework would make efficient use of limited resources.

The absence of statistically significant predictors warrants careful interpretation and should not be read as evidence of no association. With 33 children and only 13 outcome events, the study was substantially underpowered to detect the modest effect sizes typical of this field; the rule of thumb of approximately ten events per variable permits essentially no multivariable adjustment, so all estimates are unadjusted and confounding cannot be excluded. The wide confidence intervals, several spanning an order of magnitude, quantify this imprecision directly, and the consistent direction of several effects (meal frequency, lower birth weight, female sex) is arguably more informative than the individual p-values. No correction for multiple comparisons was applied, given the exploratory, hypothesis-generating intent. These considerations frame the present analysis as a clinically grounded characterisation that should inform the design of an adequately powered, comparative successor study rather than as a source of definitive risk estimates.

## Limitations

Several limitations should be considered when interpreting these findings. The sample was small (n = 33) with only 13 outcome events, yielding wide confidence intervals and precluding multivariable adjustment; analyses were therefore unadjusted, exploratory and not corrected for multiple comparisons. The single-arm design, without a contemporaneous non-exposed comparison group, means the excess risk attributable to GDM cannot be quantified. Because current child parameters were obtained by maternal telephone interview, some variables are subject to recall and reporting bias, and a small number of items had missing data. In addition, the cohort was restricted to the 33 of 42 eligible women (78.6%) for whom complete records were available, and the nine pregnancies without extractable records may differ systematically from those analysed, raising the possibility of selection bias. Finally, as a single-jurisdiction cohort assembled over a defined six-month window, the findings may not be generalisable to all GDM-exposed children. Residual confounding is also likely, since several maternal variables known to influence offspring adiposity (notably pre-pregnancy body mass index, gestational weight gain and socioeconomic status) were not available for adjustment. Because current weight and height were largely maternally reported during the telephone interview rather than measured directly, some anthropometric misclassification is also possible. These findings should accordingly be regarded as hypothesis-generating.

## Recommendations for Future Research

Several priorities for future research follow from this work. The findings should be confirmed and extended through adequately powered, prospective multicentre cohort studies, since recruitment across several sites would improve both precision and generalisability. Such studies should ideally incorporate a contemporaneous non-GDM comparison group, without which the excess risk attributable to in-utero exposure cannot be quantified. They would also benefit from richer phenotyping than was possible here: measurement of insulin-resistance biomarkers (for example, fasting insulin and HOMA-IR) together with HbA1c would allow early dysglycaemia to be detected before it becomes clinically apparent, while waist circumference and a direct estimate of body-fat percentage would characterise adiposity more completely than body mass index alone. Analyses should also account for pubertal status, which strongly influences body composition in middle childhood and adolescence. Finally, longitudinal growth trajectories captured from birth, rather than single time-point anthropometry, would clarify whether later adiposity in GDM-exposed children is driven more by the pattern of post-natal growth, particularly rapid catch-up growth, than by birth size. Together, these additions would provide the stronger, comparative evidence needed to guide screening and early intervention in this population.

## Conclusion

In this retrospective cohort of children exposed to gestational diabetes mellitus (GDM) in utero in Guyana, nearly 40% were overweight or obese by nine years of age, while one-quarter had been macrosomic at birth, highlighting a considerable early cardiometabolic burden. Although no independent predictors of abnormal BMI were identified, likely due to the limited sample size, higher meal frequency, lower birth weight, and female sex emerged as important trends warranting further investigation. These findings support routine, long-term anthropometric and metabolic monitoring of GDM-exposed children and highlight the need for larger comparative studies to identify modifiable risk factors. Integrating such follow-up into maternal and child health

services in Guyana and similar resource-constrained settings could facilitate early intervention and help reduce the future burden of obesity and cardiometabolic disease.

## Conflict of Interest

The authors declared that there is no conflict of interest.

## Ethical Approval

This study was conducted as part of a PhD research programme approved by the Ministry of Health Guyana Institutional Review Board, the GPHC Research Committee, and governed by Texila American University institutional research oversight. All data was de-identified; study IDs replaced hospital medical record numbers in all analytical datasets. No participant intervention was involved in this retrospective record review. The study was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from the mothers of participating children prior to the telephone interviews, and all data was de-identified before analysis.

## Author Contributions

Dr. Samantha N.A. Kennedy conceived and designed the study, acquired, analysed and interpreted the data, and drafted the manuscript. Dr. Michael Olabode Tomori provided PhD supervision, academic oversight, critical manuscript review, and interpretation of findings. Dr. Abiodun Olaiya Paul contributed to the methodology, scientific review, and manuscript editing. All authors approved the final manuscript and accepted responsibility for its content.

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## Data Availability

The de-identified dataset supporting the findings of this study is available from the corresponding author on reasonable request, subject to Ministry of Health data-governance approval.

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# Governance Quality, Institutional Stability, and Child Stunting in Sub-Saharan Africa: A Multi-Country Analysis of SDG 16 Pathways, 2015–2024

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***Abstract*** *Child stunting affects over 66 million children in sub-Saharan Africa (SSA), representing 60% of the global burden. While food insecurity, poverty, and climate shocks explain part of this burden, the governance mechanisms linking institutional quality to malnutrition outcomes remain poorly quantified. This study examines whether and through which pathways governance quality and institutional stability (SDG 16) influence child stunting prevalence across 49 SSA countries over the period 2015–2024. Using an unbalanced cross-sectional dataset combining UNICEF/WHO/World Bank Joint Malnutrition Estimates, World Bank Worldwide Governance Indicators (WGI), and 20+ SDG proxy indicators, we employed a series of six nested ordinary least squares (OLS) regression models with progressive covariate adjustment, complemented by principal component analysis (PCA) for governance index construction and k-means clustering for country typology. Results indicate that the composite governance index (ICOMP_GOV_ACP) explains 46.5% of stunting variance in baseline models (M1: $R^2adj=0.465$, $F=21.870$, $p<0.001$), but this effect is fully mediated in the parsimonious model (M5: $R^2adj=0.643$, $F=21.283$, $p<0.001$) by three proximal determinants: skilled birth attendance (SBA_LAST, $\beta=-0.414$, $p=0.002$), food insecurity (FIES_LAST, $\beta=+0.325$, $p=0.091$), and electricity access (ELEC_LAST, $\beta=-0.327$, $p=0.116$). These findings establish governance as a distal determinant operating through service-delivery pathways, with implications for integrated SDG 16–2–3–7 policy strategies. We accordingly recommend that governance investments be systematically paired with targeted food security programmes and expansion of skilled birth attendance coverage to achieve meaningful reductions in stunting prevalence across sub-Saharan Africa.*

***Keywords*** *Child Stunting, Food Insecurity, Governance, OLS Regression, SDG 16, Sub-Saharan Africa.*

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## Introduction

Child stunting, defined as height-for-age more than two standard deviations below the World Health Organization (WHO) median, remains one of the most pervasive manifestations of chronic malnutrition in sub-Saharan Africa (SSA). In 2024, approximately 66 million children under five in SSA were estimated to be stunted, representing 60% of the global burden [1]. Despite decades of nutritional interventions, the decline in stunting prevalence in SSA has been slower than in other regions, with significant heterogeneity across countries: prevalence ranges from 8.7% in Gabon to 56.5% in Burundi, suggesting that country-level structural factors play a decisive role beyond individual-level nutrition determinants [2, 3].

The Sustainable Development Goals (SDGs) framework offers a multi-dimensional lens for understanding this heterogeneity. SDG 2 (Zero Hunger) explicitly targets stunting elimination, while SDG 16 (Peace, Justice, and Strong Institutions) addresses the governance infrastructure that enables effective public service delivery. Theoretical linkages between governance quality and nutrition outcomes have been proposed through multiple channels: institutional capacity to design and implement nutrition policies, government effectiveness in delivering health, water, and sanitation services, political stability enabling sustained programme continuity, and the rule of law as a mechanism ensuring accountability in budget allocation [4, 5].

Empirically, however, the independent contribution of governance to stunting net of economic development, food security, and health infrastructure has rarely been quantified in multi-country studies covering the full SSA region. Most existing analyses either focus on single countries, use governance as a control variable rather than the primary explanatory variable, or fail to account for the mediating pathways through which governance translates into nutrition outcomes [6-8]. This gap is consequential: if governance effects are mediated by food security and health service access, then SDG 16 investments must be coupled with SDG 2 and SDG 3 interventions to reduce stunting effectively.

This paper addresses this gap through a systematic multi-country analysis of 49 SSA countries, employing six nested OLS regression models, PCA-based governance index construction, k-means cluster analysis, and mediation pathway identification. Our central research question is: To what extent does governance quality (SDG 16) explain inter-country variation in child stunting prevalence in SSA, and through which proximal pathways does this effect operate?

Our contribution operates on three levels. Most fundamentally, we provide the first comprehensive quantification of the governance-stunting relationship across all 49 SSA countries using the 2015–2024 observation window. Building on this, we decompose the relationship into direct and mediated effects, identifying skilled birth attendance, food insecurity, and electricity access as the key transmission channels. Taken together, these findings directly inform the policy debate on how SDG 16 implementation can accelerate progress on SDG 2 and SDG 3 nutrition targets.

## Materials and Methods

### Study Design and Data Sources

Our study employed a multi-country ecological design using harmonized country-level indicators from 49 Sub-Saharan African countries covering the period 2015–2024. Annual observations for each indicator were compiled from internationally recognized databases and aggregated into country-level averages for the 2015–2024 period. These averaged indicators were subsequently used as the basis for all statistical analyses. Data were compiled from six primary sources, including the UNICEF/WHO/World Bank Joint

Malnutrition Estimates (JME 2025) for stunting prevalence, the World Bank Worldwide Governance Indicators (WGI 2022) for five governance dimensions [9], the FAO State of Food Security and Nutrition in the World (SOFI 2024) for food insecurity, the WHO/UNICEF Joint Monitoring Programme (JMP) for water and sanitation access [10], the World Bank World Development Indicators (WDI 2024) for economic and demographic controls, and World Bank energy statistics (ESMAP 2022) for electricity access [11].

## Variable Operationalization

### Dependent Variable

STUNT_LAST: Prevalence of stunting (height-for-age < −2 SD) among children under five years of age [12] (%), from the most recent available survey per country (2015–2024). Source: JME OMS/UNICEF/WB 2025.

### Independent Variables — Governance (SDG 16)

Five World Bank WGI dimensions were used: Government Effectiveness (WGI_GE), Political Stability and Absence of Violence (WGI_PV), Rule of Law (WGI_RL), Control of Corruption (WGI_CC), and Voice and Accountability (WGI_VA). All dimensions are standardized scores ranging from approximately −2.5 to +2.5. Given very high inter-indicator correlations (r≥0.85), a composite governance index (ICOMP_GOV_ACP) was constructed using principal component analysis (PCA), retaining the first component (explaining 84.4% of variance). Individual WGI dimensions were also tested separately in robustness Model M6.

### Control Variables

Controls included: log gross domestic product per capita (LN_GDP, WB WDI 2024), Food Insecurity Experience Scale prevalence (FIES_LAST, FAO SOFI 2024, SDG 2.1.2), access to safely managed drinking water (EAU_LAST, JMP, SDG 6.1.1), skilled birth attendance coverage (SBA_LAST, WHO, SDG 3.1.2), access to electricity (ELEC_LAST, ESMAP, SDG 7.1.1), GINI coefficient (WB WDI), poverty rate at $2.15/day (POV215, SDG 1.1.1), and child marriage rate (MARM_LAST, SDG 5.3.1). Under-five mortality (U5MR) and maternal mortality ratio (MMR) were considered but excluded from primary models due to high collinearity with SBA_LAST (r≥0.80).

## Statistical Analysis

Analyses were conducted in IBM SPSS Statistics 27. The analytical strategy proceeded through six sequential steps:

1. **Step 1 — Descriptive Statistics:** Means, medians, standard deviations, skewness, kurtosis, and Shapiro–Wilk normality tests for all variables. STUNT_LAST presented approximately normal distribution (skewness=0.23, Shapiro–Wilk p=0.245), allowing direct use without transformation.
2. **Step 2 — Bivariate Correlations:** Pearson and Spearman correlation matrices to identify preliminary associations and potential collinearity issues.
3. **Step 3 — PCA for Governance Index:** Principal component analysis on the five WGI dimensions to construct ICOMP_GOV_ACP. Kaiser–Meyer–Olkin (KMO) adequacy [13] and Bartlett sphericity tests confirmed the appropriateness of PCA.
4. **Step 4 — K-Means Cluster Analysis:** Countries were classified into four typological groups based on their combined governance-stunting profile, using Ward's hierarchical method to initialize centroids and k-means for final assignment.
5. **Step 5 — OLS Regression:** Six nested models (M1–M6) with progressive covariate addition. Collinearity was assessed through Variance Inflation Factors (VIF) and condition indices. Residual diagnostics included Durbin–

Watson tests [14], P-P plots, and standardized residual scatter plots. Robust standard errors (HC3) were applied [15] where heteroscedasticity was detected.

6. **Step 6 — Robustness:** Model M6 re-estimated with individual WGI dimensions replacing ICOMP_GOV_ACP to verify PCA index validity.

# Results

## Descriptive Statistics

Table 1 presents descriptive statistics for all primary variables. Mean stunting prevalence across the 49 SSA countries was 28.0% (SD=10.6%), ranging from 8.7% (Gabon) to 56.5% (Burundi), reflecting substantial inter-country heterogeneity. The composite governance index ICOMP_GOV_ACP, by construction a standardized z-score (mean=0, SD=1), ranged from −2.05 (conflict-affected states) to +1.62 (Mauritius, Rwanda), providing adequate variance for regression analysis.

Mean food insecurity (FIES_LAST) stood at 55.2% (SD=16.4%), with a range from 17.2% to 80.0%, confirming the scale of the food security crisis across SSA. Skilled birth attendance (SBA_LAST) averaged 65.4% (SD=24.8%), with the large standard deviation reflecting the gap between well-performing health systems (Seychelles: 100%) and fragile states (South Sudan: 9.0%). Electricity access averaged 52.3% of the population.

**Table 1.** Descriptive Statistics of Key Variables — 49 Sub-Saharan African Countries

| Variable | N | Mean | Median | SD | Min | Max | Skewness |
|---|---|---|---|---|---|---|---|
| STUNT_LAST (%) | 49 | 28.0 | 28.5 | 10.6 | 8.7 | 56.5 | 0.23 |
| ICOMP_GOV_ACP | 49 | 0.00 | −0.21 | 1.00 | −2.05 | +1.62 | 0.31 |
| FIES_LAST (%) | 46 | 55.2 | 58.4 | 16.4 | 17.2 | 80.0 | −0.61 |
| SBA_LAST (%) | 46 | 65.4 | 68.5 | 24.8 | 9.0 | 100.0 | −0.47 |
| ELEC_LAST (%) | 46 | 52.3 | 51.0 | 28.7 | 4.0 | 100.0 | 0.07 |
| EAU_LAST (%) | 45 | 37.2 | 30.0 | 23.1 | 5.0 | 100.0 | 0.82 |
| LN_GDP | 49 | 7.42 | 7.38 | 0.79 | 5.72 | 9.34 | 0.14 |

Note: STUNT_LAST = stunting prevalence (%); ICOMP_GOV_ACP = composite governance index (PCA score, z-score); FIES_LAST = food insecurity prevalence (%); SBA_LAST = skilled birth attendance (%); ELEC_LAST = electricity access (%); EAU_LAST = safe water access (%); LN_GDP = log GDP per capita.

## Bivariate Correlations

Pearson correlation analysis revealed strong bivariate associations consistent with theoretical expectations. STUNT_LAST was significantly negatively correlated with ICOMP_GOV_ACP ($r=-0.628$, $p<0.001$), confirming that countries with stronger governance institutions tend to have lower stunting prevalence. The governance-stunting correlation was comparable in magnitude to the food insecurity correlation (STUNT×FIES: $r=+0.741$, $p<0.001$), suggesting that governance quality is a structural determinant of comparable importance to food security in explaining inter-country stunting variation.

Importantly, all five WGI dimensions were highly intercorrelated ($r\geq0.82$ for all pairs, VIF up to 83.9 when included jointly in Model M6), justifying the PCA approach to governance index construction. The composite index ICOMP_GOV_ACP was also strongly correlated with LN_GDP ($r=+0.683$, $p<0.001$), necessitating joint inclusion to isolate governance effects net of economic development.

## Principal Component Analysis — Governance Index

PCA on the five WGI dimensions yielded strong results. KMO=0.844 (good) and Bartlett's sphericity test ($p<0.001$) confirmed

adequacy. The first principal component (ICOMP_GOV_ACP) explained 84.4% of the total variance across the five governance dimensions, well exceeding the 70% threshold for single-component adequacy. All five WGI dimensions loaded strongly on this component (loadings between 0.883 and 0.941), confirming that a single governance dimension underlies the WGI structure in SSA. This composite index was used as the primary governance predictor in Models M1–M5.

## Country Typology — K-Means Cluster Analysis

K-means clustering (k=4) identified four distinct country typologies based on combined governance and stunting profiles. Group 1 (Strong Governance / Low Stunting, n=9): Mauritius, Cabo Verde, Seychelles, Botswana, Rwanda, Ghana, Namibia, South Africa, Senegal — mean stunting=18.9%, mean ICOMP_GOV_ACP=+0.92. Group 2 (Moderate Vulnerability, n=14): Kenya, Tanzania, Côte d'Ivoire, Cameroon, Uganda, Ethiopia, Zambia — mean stunting=25.4%, mean governance=−0.31. Group 3 (High Climate Risk / Elevated Stunting, n=12): Niger, Mali, Angola, Mozambique, Madagascar, D.R. Congo — mean stunting=26.1%, mean governance=−0.78. Group 4 (Fragile States / Crisis Stunting, n=14): South Sudan, Central African Republic, Chad, Somalia, Burundi, Guinea-Bissau — mean stunting=42.0%, mean governance=−1.44. These four clusters showed highly significant stunting differentiation (one-way ANOVA: $F=28.4$, $p<0.001$, $\eta^2=0.64$).

## OLS Regression Results

Table 2 presents the summary statistics for all six regression models. All models were statistically significant (F-statistics $p<0.001$) with Durbin-Watson values between 1.985 and 2.409, confirming absence of residual autocorrelation. PP Plots and standardized residual scatter plots confirmed normality and homoscedasticity for all models.

**Table 2.** Summary of OLS Regression Models M1–M6 — Dependent Variable: STUNT_LAST

| Model | R | $R^2$ | $R^2$adj. | F | Sig. | DW | N |
|---|---|---|---|---|---|---|---|
| M1: ICOMP_GOV + LN_GDP | .698 | .487 | .465 | 21.870 | <.001*** | 1.985 | 49 |
| M2: M1 + FIES + EAU | .796 | .634 | .597 | 17.291 | <.001*** | 1.998 | 45 |
| M3: M2 + ELEC + SBA + CSU | .859 | .738 | .688 | 14.858 | <.001*** | 2.409 | 45 |
| M4: M3(-CSU) + GINI + POV + MARM | .877 | .769 | .707 | 12.550 | <.001*** | 2.288 | 44 |
| M5: Parsimonious (Reference) | .822 | .675 | .643 | 21.283 | <.001*** | 1.998 | 46 |
| M6: Individual WGI (Robustness) | .745 | .555 | .492 | 8.748 | <.001*** | 2.189 | 49 |

Note: *** p<0.001; ** p<0.01; * p<0.05; † p<0.10. DW = Durbin-Watson statistic. VIF values for all predictors were below 8.0 in M1–M5.

## Model M1 — Governance Baseline

The baseline model (M1) including only ICOMP_GOV_ACP and LN_GDP explained 46.5% of stunting variance ($R^2$adj=0.465, $F=21.870$, $p<0.001$, $N=49$). ICOMP_GOV_ACP was statistically significant ($\beta=-0.393$, $B=-4.001$, $p=0.005$**), indicating that each standard deviation increase in governance quality is associated with a 4.0 percentage point reduction in stunting prevalence. LN_GDP was also significant ($\beta=-0.387$, $p=0.007$**), confirming the well-established income-nutrition relationship. VIF

values (1.627) confirmed negligible collinearity in this model.

## Models M2–M4 — Progressive Covariate Addition

Adding food insecurity and water access in M2 ($R^2adj$=0.597) substantially reduced the ICOMP_GOV_ACP coefficient, consistent with partial mediation through food security pathways. The addition of electricity access and skilled birth attendance in M3 ($R^2adj$=0.688, N=45) further attenuated the governance coefficient, while SBA_LAST emerged as a strong independent predictor (β=−0.376, p=0.003**). Model M4 ($R^2adj$=0.707), including inequalities (GINI), poverty (POV215), and child marriage (MARM_LAST), achieved the highest adjusted $R^2$ of the series, with SBA_LAST remaining the most consistently significant predictor.

## Model M5 — Parsimonious Reference Model

The parsimonious Model M5, including ICOMP_GOV_ACP, FIES_LAST, SBA_LAST, and ELEC_LAST, achieved $R^2adj$=0.643 with the highest F-statistic of the series (F=21.283, p<0.001, N=46). Table 3 presents the full coefficient table for this reference model. The governance index ICOMP_GOV_ACP was no longer independently significant (β=−0.127, p=0.406 ns), consistent with full mediation: its effect is entirely transmitted through the three proximal determinants in the model. SBA_LAST was the strongest significant predictor (β=−0.414, B=−0.246, p=0.002**), followed by FIES_LAST (β=+0.325, p=0.091†) and ELEC_LAST (β=−0.327, p=0.116 ns). The coefficient for SBA_LAST indicates that a 10 percentage point increase in skilled birth attendance coverage is associated with a 2.5 percentage point reduction in stunting prevalence, net of governance, food security, and electricity access.

**Table 3.** OLS Coefficients — Model M5 (Parsimonious Reference Model), N=46

| Variable | B | SE(B) | β std | t | Sig. | 95% CI Low | 95% CI High | Tol. | VIF |
|---|---|---|---|---|---|---|---|---|---|
| Constant | 52.341 | 14.218 | — | 3.681 | <.001*** | 23.675 | 81.007 | — | — |
| ICOMP_GOV_ACP | −1.293 | 1.541 | −0.127 | −0.839 | .406 ns | −4.410 | 1.823 | .303 | 3.300 |
| FIES_LAST *** | +0.198 | 0.115 | +0.325 | 1.727 | .091 † | −0.033 | 0.430 | .272 | 3.681 |
| SBA_LAST *** | −0.246 | 0.075 | −0.414 | −3.286 | .002** | −0.398 | −0.094 | .454 | 2.203 |
| ELEC_LAST * | −0.121 | 0.075 | −0.327 | −1.605 | .116 ns | −0.273 | 0.031 | .137 | 7.284 |

Note: *** p<0.001; ** p<0.01; * p<0.05; † p<0.10; ns=not significant. DW=1.998; $R^2adj$=0.643; F(4,41)=21.283, p<0.001. VIF max=7.284 (ELEC_LAST, due to partial collinearity with ICOMP_GOV_ACP). All other VIF<3.7.

## Model M6 — Robustness with Individual WGI

Robustness Model M6, replacing ICOMP_GOV_ACP with the five individual WGI dimensions, produced $R^2adj$=0.492 (N=49), substantially lower than M1–M5, confirming that the PCA composite index is more informative than any individual WGI dimension. Extreme VIF values (WGI_RL=83.953) confirmed the severe multicollinearity that motivates the PCA approach. Among individual WGI dimensions, Government Effectiveness (WGI_GE) showed the strongest association with stunting (β=−0.381, p=0.048*), consistent with the theoretical emphasis on implementation capacity in health and nutrition programs.

## Discussion

This study provides robust multi-country evidence that governance quality (SDG 16) is a statistically significant distal determinant of child stunting in SSA, but that its effect is fully mediated by three proximal pathways: maternal health service quality (SBA_LAST), food insecurity (FIES_LAST), and energy access (ELEC_LAST). These findings are consistent with the capability approach [16] and with recent evidence showing that institutional quality affects nutrition primarily through its effect on public service delivery rather than through direct nutritional interventions [17, 18].

The magnitude of the governance-stunting relationship in our baseline model (β=−4.0 pp per governance standard deviation, M1) is consistent with existing cross-country estimates. Black et al. [19] estimated that political instability reduces child nutrition outcomes by 3–6 pp across comparable samples, while Guerrant et al. [20] documented governance effects of 4–8 pp in African health system analyses. The transition from M1 (ICOMP_GOV significant) to M5 (ICOMP_GOV non-significant) constitutes formal evidence of mediation, addressing a key gap in the existing literature.

The emergence of SBA_LAST as the strongest proximal determinant (β=−0.414, p=0.002** in M5) is theoretically important. Skilled birth attendance captures both access to maternal health services at delivery and the broader quality of primary healthcare infrastructure. This finding aligns with the Lancet Series on Maternal and Child Nutrition [21, 22], which identified the 1,000-day window (conception to age 2) as the critical period for stunting prevention, during which skilled birth attendance, exclusive breastfeeding support, and growth monitoring represent the highest-leverage interventions.

The finding that FIES_LAST (β=+0.325, p=0.091) maintains a positive and near-significant association with stunting even after controlling for governance and health infrastructure suggests that food insecurity has both governance-mediated and direct effects on stunting. Countries with equivalent governance quality but higher food insecurity continue to exhibit higher stunting, consistent with the proximal importance of dietary intake adequacy documented by Victora et al. [23]. This result directly supports the complementarity argument: SDG 16 governance investments must be paired with SDG 2 food security interventions to achieve maximum impact on stunting [24].

The apparent sign reversal of CLI_RISK in M2 of Article 2 (B=−0.014, ns) — counter to the expected positive effect — reflects the suppression of climate risk effects by FIES_LAST: in countries where food insecurity already captures climate vulnerability exposure, the residual marginal effect of the INFORM risk index on stunting becomes negligible. This cross-article finding strengthens the argument that food insecurity is the key transmission channel between climate risk and child nutrition outcomes.

Country-level case analysis from the cluster results further illuminates the governance-stunting nexus. Rwanda (Group 1) reduced stunting from 44% (2015) to 33% (2022) alongside major governance reforms (Vision 2020 Umurenge social protection program, community health worker system scale-up). Ghana (Group 1, stunting=17.8%) demonstrates how democratic consolidation combined with community-based nutrition programs can achieve low stunting despite moderate income levels. Conversely, South Sudan and Central African Republic (Group 4, mean stunting=42%) illustrate how governance breakdown reverses nutrition gains: the destruction of health infrastructure, displacement of health workers, and collapse of food systems combine to produce acute malnutrition crises [25].

## Conclusion

This multi-country analysis of 49 SSA countries demonstrates that governance quality (SDG 16) is a statistically robust and quantitatively significant distal determinant of child stunting, explaining 46.5% of inter-country variance in baseline models. However, this effect is fully mediated by three proximal mechanisms — skilled birth attendance, food insecurity, and electricity access — which together explain 64.3% of stunting variance in the parsimonious model. These findings establish a clear policy logic: SDG 16 investments in institutional capacity are necessary but not sufficient to reduce stunting; they must be paired with targeted SDG 2 (food security), SDG 3 (maternal health), and SDG 7 (energy) interventions to achieve maximum impact.

These findings carry direct policy implications. Countries with strong governance but persisting high stunting — Rwanda and Ethiopia being notable examples — stand to gain most from scaling skilled birth attendance and community health worker programmes targeting the 1,000-day window, where governance already provides the implementation infrastructure. Where governance remains weak, the analysis suggests that waiting for institutional reform before addressing malnutrition is not viable: immediate food security safety nets must run in parallel, since governance reforms unfold over years while acute malnutrition demands a shorter-term response. At the programme-design level, the four-cluster typology developed here offers a practical targeting tool for international donors and national governments seeking to allocate resources according to governance-stunting profiles. More broadly, the consistently strong mediation role of skilled birth attendance points to maternal health system capacity as the single highest-leverage investment that governance improvement can unlock.

Several limitations warrant acknowledgement. The cross-sectional design restricts causal inference, and the reliance on country-level ecological data introduces the risk of ecological fallacy — findings describe aggregate patterns and cannot be directly transposed to individual-level relationships. Measurement error in some SDG indicators, particularly for countries with older survey data, also limits precision. Unobserved heterogeneity that panel methods could capture remains beyond the reach of this design. Future work should tackle endogeneity more directly, for instance through instrumental variable approaches using colonial heritage as an exogenous governance instrument, and extend the analysis to panel data covering the full 2015–2024 period to track governance-nutrition dynamics over time.

## Conflict of Interest

The author declares no conflict of interest.

## Ethical Approval

This study used publicly available, anonymized, country-level aggregate data from international organizations (WHO, UNICEF, World Bank, FAO). No individual-level data were collected or used. Ethical approval was not required for this type of secondary ecological analysis.

## Data Availability Statement

All data used in this study are publicly available from international organisations. Stunting prevalence data are accessible via the UNICEF/WHO/World Bank Joint Malnutrition Estimates portal (https://data.unicef.org/topic/nutrition/). Governance indicators are available from the World Bank WGI database (https://info.worldbank.org/governance/wgi/). Food insecurity data derive from the FAO SOFI report series (https://www.fao.org/publications/sofi). Water and sanitation data are from the WHO/UNICEF Joint Monitoring Programme

(https://washdata.org/). Economic indicators are from the World Bank World Development Indicators (https://databank.worldbank.org/source/world-development-indicators), and energy access data from the World Bank ESMAP portal (https://trackingsdg7.esmap.org/). No new data were created for this study.

## Author Contributions

Eveline Ngwenyi: Conceptualization, Methodology, Formal Analysis, Data Curation, Writing — Original Draft, Writing — Review & Editing.

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# Health Consequences and Intimate Partner Relationships of Women with Genital Mutilation Experiences: A Cross-Sectional Comparative Study in South-East Nigeria

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***Abstract*** *Female genital mutilation (FGM) remains a deeply rooted cultural practice with severe physical and psychological consequences. Despite global eradication efforts, it persists in parts of Nigeria where sociocultural norms override legal and health frameworks. This study explores the lived experiences of women in Eastern Nigeria who have undergone FGM, emphasizing their physical and psychological health outcomes. A comparative mixed-methods design was adopted, involving 300 women aged 18–69 years across six local government areas in Imo and Ebonyi States. Quantitative data were collected using validated instruments PHQ-9, GAD-7, EIS, and PCL-5, and analyzed with descriptive statistics, chi-square tests, and logistic regression. Qualitative insights were derived from seven key informant interviews and two focus group discussions, analyzed through inductive thematic coding using NVivo 12. Women who had undergone FGM reported significantly higher rates of immediate complications such as bleeding, pain, and infection, and long-term sequelae including dyspareunia, menstrual pain, and reduced sexual satisfaction ($p < 0.001$). Psychological outcomes revealed elevated depressive and anxiety symptoms, with mean PHQ-9 and GAD-7 scores of 17.2 ± 5.1 and 14.9 ± 4.8, respectively, compared to 11.3 ± 4.6 and 9.8 ± 4.2 among women without FGM. Qualitative themes underscored trauma, shame, emotional withdrawal, and relational disconnection, illustrating the interdependence of physical and psychological suffering. FGM continues to impose multidimensional harm on women's health in Eastern Nigeria. Findings highlight the need for trauma-informed interventions that integrate clinical care, psychosocial support, and community re-education to mitigate both physical and emotional aftermaths. A holistic response combining medical rehabilitation and culturally sensitive counseling is imperative for survivor-centered healing and sustainable eradication efforts.*

***Keywords*** *Anxiety, Depression, Female Genital Mutilation, Psychological Trauma, Sexual Health.*

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## Introduction

Female Genital Mutilation (FGM), also referred to as female cutting or circumcision, remains one of the most deep-seated traditional practices affecting women's physical and psychological health in Africa and beyond [1, 2]. Globally, an estimated 230 million girls and women have undergone the practice, with over four million girls at risk each year [3, 4]. Nigeria accounts for nearly 10% of this global burden, representing more than 20 million survivors, many of whom reside in the eastern and southeastern parts of the country where cultural and communal values strongly reinforce adherence [5] Although often justified by social ideals of chastity, purity, and marriageability, the procedure inflicts profound physical trauma and enduring psychological distress [6].

The problem of this study arises from the multidimensional harm caused by FGM to women's health and well-being. While early research predominantly examined obstetric complications such as prolonged labour, perineal tears, and postpartum haemorrhage [7, 8] there is a growing recognition that the practice also disrupts women's psychological health. Survivors frequently report symptoms of depression, anxiety, post-traumatic stress, and sexual dysfunction, conditions that persist long after the initial procedure and often erode their self-esteem, emotional well-being, and marital intimacy [9-11]. Despite the legal prohibition of FGM through the Violence Against Persons (Prohibition) Act [12], and the existence of global advocacy frameworks under Sustainable Development Goal 5.3, the persistence of the practice in Eastern Nigeria demonstrates a gap between policy and lived experience.

Several existing solutions have been implemented to curb the practice, including legislative bans, community sensitization, and the involvement of healthcare providers in anti-FGM campaigns [13, 14]. However, these interventions often focus narrowly on physical harm or human rights violations, without integrating mental health care or trauma-informed counseling for survivors. Furthermore, the medicalization of FGM, where health professionals perform the procedure under the guise of safety, has unintentionally legitimized the act and undermined eradication efforts [15].

The best approach emerging from recent evidence advocates a holistic model, combining psychosocial rehabilitation, community re-education, and culturally sensitive health interventions [9, 10]. This integrative strategy emphasizes that addressing FGM's consequences requires attention not only to physical recovery but also to emotional healing and relational stability among affected women.

Nonetheless, significant limitations persist. Empirical data on the lived psychological consequences of FGM in Nigeria remain scarce. Most studies have focused on obstetric or sexual outcomes, while few have examined how physical pain interacts with trauma, fear, and shame to shape women's mental health trajectories. Cultural taboos around discussing sexuality and emotional distress further hinder research and care-seeking [16, 10]. Moreover, weak enforcement of anti-FGM laws and the sociocultural authority of traditional leaders limit the reach of interventions [17, 14].

Despite these challenges, there have been notable achievements in the global and national campaign against FGM. Nigeria's inclusion of FGM eradication within its gender and health policies represents a major step toward systemic action [13]. Community dialogues and grassroots education programs have led to localized declines in some regions [18]. More importantly, the growing body of interdisciplinary research, linking FGM to both psychological trauma and impaired reproductive outcomes, has illuminated the urgent need for context-specific interventions [19, 20].

The objective of this study is to explore the lived experiences of women in Eastern Nigeria who have undergone FGM, with particular emphasis on their physical and psychological health outcomes. It aims to understand how physical injuries, such as chronic pain and reproductive complications, intertwine with psychological sequelae, including depression, anxiety, and post-traumatic stress, to shape women's everyday functioning and well-being.

The novelty of this work lies in its focus on integrating physical and psychological perspectives to produce a more holistic understanding of FGM's consequences within a culturally grounded Nigerian context. Unlike prior studies that treated these domains separately, this research investigates how bodily harm and emotional trauma co-exist and reinforce one another in shaping women's lived experiences. By foregrounding survivors' voices and grounding analysis in socio-cultural realities, this study contributes new empirical evidence to support trauma-informed, gender-sensitive health interventions and community education strategies.

## Materials and Methods

### Study Site

The study was conducted in selected rural communities of Ebonyi and Imo States, both located in South-East Nigeria region reported to have a relatively high prevalence of female genital mutilation/cutting (FGM/C) [21]. Six Local Government Areas (LGAs) were purposively selected: Oru West, Orsu, and Okigwe in Imo State, and Abakaliki, Ikwo, and Ohaozara in Ebonyi State. These areas were chosen based on documented cultural adherence to the practice and the limited availability of sexual and reproductive health services, providing an appropriate sociocultural context to explore the physical, psychological, and relational implications of FGM/C [22]. Participant entry was facilitated through engagement with community leaders, health workers, local NGOs, and women's organizations.

### Study Design

The study employed a comparative mixed-methods design, integrating both quantitative and qualitative components. This triangulated method was chosen to ensure a comprehensive exploration of the health consequences and intimate partner relationship dynamics of women who have undergone Female Genital Mutilation/Cutting (FGM/C) in South-East Nigeria. By combining both numerical data and in-depth narratives, the study aims to capture the multifaceted impact of FGM/C on physical health, psychological well-being, and relational outcomes.

### Sampling Technique and Participant Criteria

A purposive sampling method was used to recruit three hundred and six (306) women aged 18 -69 years, Participants were divided equally into two groups: women who had undergone FGM/C (n = 153) and women who had not (n = 153). Participants were selected based on their willingness to provide informed consent and their history of being in intimate partner relationships. Women with severe mental or physical conditions or under 18 years and above 69 years were excluded.

### Data Collection

Data collection was carried out by six trained research assistants who were final-year BSc Public Health students familiar with the local dialects. They received two days of training on ethical interviewing, confidentiality, and standardized administration of instruments. For the qualitative component, seven Key Informant Interviews (KIIs) were conducted with healthcare workers, NGO representatives, and survivors, while two Focus Group Discussions (FGDs) were organized with seven participants each. Discussions were conducted

in private, serene environments to ensure participants' comfort, confidentiality, and openness in sharing sensitive experiences.

Quantitatively, structured questionnaires and standardized psychological assessments were administered to 306 women aged 18–69 years. Participants were divided equally into two groups: women who had undergone FGM/C (n = 153) and women who had not (n = 153). Quantitative tools included the Patient Health Questionnaire-9 (PHQ-9) for depressive symptoms [21], the Generalized Anxiety Disorder-7 (GAD-7) for anxiety levels [23], the Emotional Intimacy Scale (EIS) for assessing relationship closeness (Sinclair & Dowdy, 2005), and the Post-Traumatic Stress Disorder Checklist for DSM-5 (PCL-5) for trauma-related symptoms [24].

Prior to the main study, all instruments were pre-tested among 20 women in a nearby community not included in the final sample to assess clarity, reliability, and contextual appropriateness. The internal consistency coefficients were satisfactory: PHQ-9 ($\alpha$ = 0.88), GAD-7 ($\alpha$ = 0.91), EIS ($\alpha$ = 0.86), and PCL-5 ($\alpha$ = 0.89), confirming strong reliability. The questionnaires were reviewed by three mental health professionals and two gender specialists for content validity, ensuring the measures appropriately captured psychological and relational outcomes within the cultural setting. No item was deemed irrelevant, and all tools demonstrated conceptual equivalence to the local context.

Validated psychological instruments served as standardized instruments for quantifying mental and emotional health outcomes. Each PHQ-9 item was scored from 0 ("not at all") to 3 ("nearly every day"), yielding a total score between 0–27, with higher scores indicating greater depressive severity [23]. The GAD-7 was similarly scored on a 0–3 Likert scale, producing total scores ranging from 0–21, where scores ≥10 indicated moderate to severe anxiety [25]. The Emotional Intimacy Scale used a 5-point Likert format (1 = strongly disagree to 5 = strongly agree), with higher scores reflecting stronger emotional closeness. The PCL-5 comprised 5 -item short form rated from 0–4, producing scores of 0-20 suggesting probable PTSD [24].

### Data Analysis

Quantitative data were coded, cleaned, and analyzed using Stata version 17. Descriptive statistics (frequencies, percentages, means, and standard deviations) summarized demographic characteristics and outcome variables. Chi-square tests assessed associations between FGM/C status and categorical variables, while independent t-tests compared mean psychological scores (PHQ-9, GAD-7, and EIS) between FGM/C and non-FGM/C groups. Binary logistic regression was used to identify predictors of depressive, anxiety, and relational distress among women with FGM/C, with statistical significance set at $p < 0.05$.

For the qualitative data, thematic analysis was employed to extract recurrent themes and patterns. Audio recordings from FGDs and KIIs were transcribed verbatim and translated from Pidgin or Igbo to English by the trained field researchers. Transcripts were imported into NVivo version 12, where two independent analysts conducted inductive coding (data-driven) with iterative comparison to ensure reliability and completeness. Emerging codes were organized into categories and overarching themes representing participants' lived experiences. Verbatim quotes were used to enrich interpretation and contextualize quantitative findings, ensuring methodological triangulation and depth of understanding.

## Results

A total of 309 questionnaires were distributed, of which 300 were correctly filled and returned, yielding a 97.1% response rate. The demographic analysis revealed that most respondents were women between the ages of 50 and 69 years, with smaller proportions in the 18–29-year bracket. The majority were

married, had completed at least secondary education, and were predominantly engaged in farming or petty trading. All participants identified as Igbo, reflecting the cultural homogeneity of the study area. See table 1 below.

**Table 1.** Sociodemographic Characteristics of Respondents (N = 300)

| Variable | Frequency (n) | Percentage (%) |
|---|---|---|
| **Age Group** | | |
| 18–29 | 43 | 14.3 |
| 30–39 | 61 | 20.3 |
| 40–49 | 58 | 19.3 |
| 50–59 | 69 | 23.0 |
| 60–69 | 69 | 23.0 |
| **Marital Status** | | |
| Married | 229 | 76.3 |
| Divorced/Separated | 26 | 8.7 |
| Widowed | 28 | 9.3 |
| Others | 17 | 5.7 |
| **Highest Education** | | |
| None | 22 | 7.3 |
| Primary | 63 | 21.0 |
| Secondary | 133 | 44.3 |
| Tertiary | 82 | 27.3 |
| **Occupation** | | |
| Farmer | 101 | 33.7 |
| Petty trader | 74 | 24.7 |
| Tailor | 33 | 11.0 |
| Teacher | 12 | 4.0 |
| Health worker | 13 | 4.3 |
| Homemaker | 19 | 6.3 |
| Unemployed | 13 | 4.3 |
| Others | 35 | 11.7 |
| **State** | | |
| Imo | 150 | 50.0 |
| Ebonyi | 150 | 50.0 |
| **Local Government Area (LGA)** | | |
| Oru West | 50 | 16.7 |
| Orsu | 50 | 16.7 |
| Okigwe | 50 | 16.7 |
| Abakaliki | 50 | 16.7 |
| Ikwo | 50 | 16.7 |
| Ohaozara | 50 | 16.7 |
| **Ethnicity** | | |
| Igbo | 300 | 100.0 |

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The study further examined the physical health complications associated with Female Genital Mutilation (FGM). Immediate and long-term effects were observed to be significantly higher among women who had undergone FGM compared to those who had not. The most commonly reported physical health challenges included excessive bleeding, swelling, infection, fever, painful urination, and chronic pelvic pain. Long-term complications such as dyspareunia, menstrual pain, recurrent vaginal infections, and diminished sexual satisfaction were also prevalent. Table 2 represents the association between FGM status and reported physical health outcomes, analyzed using chi-square statistics.

**Table 2.** Association between FGM Status and Physical Health Outcomes (N = 300)

| **Complication Type** | **FGM (n=150) n (%)** | **Non-FGM (n=150) n (%)** | **$\chi^2$** | **p-value** |
|---|---|---|---|---|
| **Immediate Complications** | | | | |
| Severe bleeding (n=60) | 60 (40.0) | 0 (0.0) | | |
| Pain & swelling (n=50) | 45 (30.0) | 5 (3.3) | 180.24 | **0.0001** |
| Fever (n=12) | 10 (6.7) | 2 (1.3) | | |
| Infection (n=23) | 20 (13.3) | 3 (2.0) | | |
| Difficulty urinating (n=5) | 5 (3.3) | 0 (0.0) | | |
| None (immediate) (n=150) | 10 (6.7) | 140 (93.3) | | |
| **Long-term Complications** | | | | |
| Painful sexual intercourse (n=40) | 40 (26.7) | 0 (0.0) | | |
| Pain during menstruation (n=40) | 35 (23.3) | 5 (3.3) | | |
| Frequent vaginal infections (n=27) | 25 (16.7) | 2 (1.3) | 162.78 | **0.001** |
| Reduced sexual sensation (n=20) | 20 (13.3) | 0 (0.0) | | |
| Menstrual irregularities (n=18) | 15 (10.0) | 3 (2.0) | | |
| None (long-term) (n=155) | 15 (10.0) | 140 (93.3) | | |

Further analyses explored the psychological health outcomes of women with FGM. The results revealed that participants who had undergone the procedure reported significantly higher mean scores on both the Patient Health Questionnaire (PHQ-9) and the Generalized Anxiety Disorder Scale (GAD-7), compared to women who had not undergone FGM. These participants also recorded lower levels of emotional intimacy with their partners. The mean PHQ-9 score for women with FGM was 17.2 (SD = 5.1), while those without FGM had a mean of 11.3 (SD = 4.6). Similarly, on the GAD-7, the mean score for women with FGM was 14.9 (SD = 4.8) compared to 9.8 (SD = 4.2) for non-FGM women. Emotional intimacy scores were also lower in the FGM group (M = 13.1, SD = 4.3) compared to the non-FGM group (M = 9.4, SD = 3.7). Table 3 presents these findings, indicating significant differences across all psychological measures.

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**Table 3.** Psychological Health Outcomes (PHQ-9, GAD-7, and Emotional Intimacy Scores) by FGM Status (N = 300)

| Outcomes | Categories/Range | FGM = Yes (n=150) | % | FGM = No (n=150) | % | Total (n=300) | % | Mean ± SD |
|---|---|---|---|---|---|---|---|---|
| **Depression (PHQ-9)** | Normal (0–5) | 10 | 6.7 | 30 | 20.0 | 40 | 13.3 | |
| | Mild (6–10) | 20 | 13.3 | 45 | 30.0 | 65 | 21.7 | |
| | Moderate (11–15) | 40 | 26.7 | 35 | 23.3 | 75 | 25.0 | |
| | Moderate Severe (16–20) | 50 | 33.3 | 30 | 20.0 | 80 | 26.7 | |
| | Severe (21–27) | 30 | 20.0 | 10 | 6.7 | 40 | 13.3 | **17.2 ± 5.1** |
| **Anxiety (GAD-7)** | Normal (0–5) | 15 | 10.0 | 40 | 26.7 | 55 | 18.3 | |
| | Mild (6–10) | 25 | 16.7 | 45 | 30.0 | 70 | 23.3 | |
| | Moderate (11–15) | 55 | 36.7 | 45 | 30.0 | 100 | 33.3 | |
| | Severe (16–21) | 55 | 36.7 | 20 | 13.3 | 75 | 25.0 | **14.9 ± 4.8** |
| **Emotional Intimacy Scale (EIS – Disconnection)** | Mild (6–10) | 25 | 16.7 | 55 | 36.7 | 80 | 26.7 | |
| | Moderate (11–17) | 70 | 46.7 | 65 | 43.3 | 135 | 45.0 | |
| | Severe (18–25) | 55 | 36.7 | 30 | 20.0 | 85 | 28.3 | **13.1 ± 4.3** |

The qualitative component of the study, derived from Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs), provided rich insights into the lived experiences of women subjected to FGM in Southeast Nigeria. Thematic analysis revealed that FGM imposes profound physical and psychological burdens, which persist long after the procedure and influence daily life, reproductive health, and emotional wellbeing.

Participants consistently reported a range of enduring physical complications. Obstetric difficulties, including prolonged labor and excessive bleeding, were frequently mentioned. Chronic pelvic and genital pain, recurrent urinary and reproductive infections, menstrual irregularities, and sexual dysfunction were commonly described. One participant shared, “I feel pain every month during menstruation it affects my relationship with my husband.” Another recounted, “I keep getting urinary infections it makes life hard.” Healthcare workers corroborated these accounts, emphasizing that women often present with complications during antenatal care and sexual health consultations. These narratives illuminate the persistent physiological burden of FGM, complementing quantitative findings that demonstrated statistically significant associations between FGM and adverse physical health outcomes.

Beyond physical health, women described profound psychological and emotional distress. Trauma, anxiety, depression, shame, regret, and social stigma were recurrently mentioned. One participant noted, “Even now, I feel anxious and embarrassed talking about it.” Another stated, “I often feel hopeless. I wish I had never gone through it.” Some women reported emotional withdrawal and reduced participation in social or intimate interactions due to fear of judgment or exposure. These experiences underscore the chronic mental health burden associated with FGM, aligning with quantitative measures of depression and anxiety (PHQ-9 and GAD-7), which revealed elevated symptom levels among affected women.

**Table 3.** Qualitative Themes and Subthemes from FGDs and KIIs (N = 30)

| Theme | Subthemes | Illustrative Quotes |
|---|---|---|
| **Physical Health Consequences** | Obstetric complications | "I bled so much during my first delivery… it was scary." |
| | Chronic pelvic/genital pain | "I feel pain every month during menstruation… it affects my relationship with my husband." |
| | Sexual dysfunction | "Intercourse is painful… I often avoid it with my husband." |
| | Recurrent urinary/reproductive infections | "I keep getting urinary infections… it makes life hard." |
| | Menstrual difficulties | "My periods are long and painful… it affects my daily life." |
| **Psychological and Emotional Effects** | Trauma/PTSD symptoms | "Sometimes I relive the pain… it haunts me at night." |
| | Anxiety | "Even now, I feel anxious talking about it… I get nervous easily." |
| | Depression and sadness | "I often feel hopeless… I wish I had never gone through it." |
| | Regret | "I regret going through it… it has affected my life negatively." |
| | Shame and social stigma | "I hide my condition… I am afraid people will judge me." |
| | Emotional withdrawal | "I avoid talking about it… I feel disconnected from others." |

Collectively, these qualitative findings highlight the interconnected nature of physical and psychological consequences of FGM. Chronic pain and sexual dysfunction exacerbate emotional distress, while trauma and anxiety often compound perceptions of physical discomfort. The narratives underscore the necessity of holistic interventions that integrate clinical care, psychosocial support, and community engagement to address both the physical and mental health dimensions of FGM.

## Discussion

The findings of this study demonstrate a significant and multifaceted impact of FGM/C on the physical health of women in Southeast Nigeria. Women who had undergone the practice reported both immediate complications, such as severe bleeding, infections, and prolonged labor, as well as long-term outcomes including chronic pain, painful intercourse, and reduced sexual satisfaction. The severity and type of FGM were critical determinants, with Type III (infibulation) linked to the most severe complications. These results align with evidence from Sudan, Somalia, and Nigeria, highlighting a biological gradient where greater tissue removal and scarring intensify health risks [26, 27]. The high predictive values identified in the logistic regression suggest these complications can serve as clinical indicators for identifying women at risk, emphasizing the potential for early detection and targeted care interventions.

Psychological outcomes were equally pronounced, with affected women reporting elevated levels of depression, anxiety, and symptoms consistent with post-traumatic

stress disorder (PTSD), alongside reduced emotional intimacy with partners. These effects were most severe among women subjected to Type III FGM or unanticipated cutting events, underscoring the traumatic nature of the procedure. Consistent with global and African studies, psychological distress was compounded by cultural and social pressures, including stigma, coercion, and expectations of social conformity [28, 29]. The interaction between physical and psychological consequences creates a cyclical burden, where chronic pain and sexual dysfunction exacerbate emotional distress, reduced self-esteem, and strained intimate relationships, highlighting the interdependence of physical trauma and mental health in FGM-affected women.

These findings carry important implications for policy, clinical practice, and community interventions. The high odds of complications such as severe bleeding and painful intercourse suggest the need for integrating reproductive health, psychosocial support, and trauma-informed care into health services for women at risk or survivors of FGM. Interventions must also address social and cultural norms that perpetuate FGM, combining legal enforcement with community-based education and empowerment programs. Promoting resilience among women, alongside culturally sensitive strategies to prevent FGM, can help mitigate long-term psychological harm while improving overall quality of life. Collectively, the study confirms that FGM/C is both a deeply entrenched cultural practice and a major public health concern, necessitating integrated approaches that address its physical, psychological, and social dimensions.

### Strengths and Limitations of Study

This study's principal strength lies in its mixed-methods design, which combined quantitative rigor with qualitative depth to provide a holistic understanding of the health, psychological, and relational consequences of Female Genital Mutilation/Cutting (FGM/C). The use of standardized instruments such as the PHQ-9, GAD-7, EIS, and PCL-5 enhanced the reliability and comparability of results, while the inclusion of both circumcised and uncircumcised women enabled meaningful comparative analysis. The study contributes novel insights by linking biomedical outcomes with psychosocial and intimate partner relationship dynamics, addressing an underexplored dimension of FGM/C research in Nigeria.

However, the cross-sectional nature of the study limits causal inference, and the reliance on self-reported data may have introduced recall or social desirability bias. The geographic focus on Imo and Ebonyi States also restricts generalizability to other cultural contexts. Moreover, while validated tools were used, some culturally specific expressions of distress may not have been fully captured. These limitations notwithstanding, the study offers valuable evidence to inform policy, advocacy, and future longitudinal research on FGM/C and women's wellbeing.

## Conclusion

This study underscores the profound and interrelated physical, psychological, and relational consequences of Female Genital Mutilation/Cutting (FGM/C) among women in South-East Nigeria. Beyond the immediate pain and medical complications, the findings reveal persistent emotional distress, sexual dysfunction, and diminished intimacy that compromise women's well-being and marital harmony. The study highlights that FGM/C is not merely a health or legal concern but a multidimensional social issue requiring trauma-informed, survivor-centered, and culturally responsive interventions. Integrating reproductive health services with mental health and community education programs remains essential to promote holistic healing,

gender equity, and the sustainable eradication of FGM/C practices

## Ethical Approval

Ethical clearance was obtained from the Research and Ethics Committee of the Alex Ekwueme Federal University Teaching Hospital, Ebonyi state with approval number AEFUTH/REC/VOL1/2024/664, in accordance with the 2013 Declaration of Helsinki and State Ministry of Health, Imo state. All procedures adhered to the ethical principles outlined in the Declaration of Helsinki for research involving human participants. Informed consent was obtained from every participant after a clear explanation of the study's objectives, procedures, potential risks, and benefits. Participation was entirely voluntary, and respondents were informed of their right to withdraw at any stage without penalty. Anonymity and confidentiality were strictly maintained throughout data collection, analysis, and reporting. Sensitive interviews were conducted in private settings to ensure participants' comfort and psychological safety, with referrals provided for those who exhibited distress during the study. The data obtained from this study were secured and password-protected in an online database accessible only to the principal investigator of the study.

## Conflict of Interest

The authors declare no conflict of interest. There are no organisations with conflicts of interest related to the study. The authors declare that they have no financial or personal relationship that might have inappropriately influenced the study design, data collection, analysis, interpretation or the writing of this paper. All procedures adhered to ethical research standards, and participant confidentiality was maintained throughout the study.

## Acknowledgements

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## Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request. Due to the sensitive nature of female genital mutilation and the ethical requirements governing participant confidentiality, individual-level qualitative transcripts and quantitative questionnaires cannot be made publicly accessible. However, anonymized datasets used for statistical analyses may be shared in compliance with the ethical approval obtained for this study and in accordance with the principles of responsible data use**.**

## Author Contributions

C. Oliver conceptualized the study, designed the methodology, coordinated data collection, conducted quantitative and qualitative analyses, and drafted the manuscript. Dr. A. O. Ndep provided supervisory oversight, contributed to methodological refinement, validated analytical approaches, and critically reviewed and edited the manuscript for intellectual content. Both authors approved the final version of the manuscript and take responsibility for the integrity and accuracy of the work.

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# Prevalence and Severity of Dyspepsia with its Impact on the Quality of Life among Medical Outpatients in a Tertiary Hospital

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***Abstract*** *Dyspepsia is a constellation of symptoms in which epigastric pain is the main presentation with a global prevalence of 7% to 45%.The aim of this study was to determine the prevalence and severity of dyspepsia and its effect on the quality of life among medical out-patients at the 34-military hospital. A systematic sampling was conducted to recruit 401 patients; a standard questionnaire used to collect information on patients' socio-demographic, clinical details, and risk factors of dyspepsia. A Short-form of the Leeds Dyspepsia Questionnaire (SF-LDQ) was used to assess symptoms and severity of dyspepsia. The Short Form Nepean Dyspepsia Index (SF-NDI) was used to assess the impact of dyspepsia on participants' quality of life. The prevalence of dyspepsia among medical outpatients at the 34 Military Hospital using the Leeds Dyspepsia Questionnaire SF-LDQ was 266(66.3%). Among patients with dyspepsia, 119(44.7%) had severe dyspepsia, 103(38.7%) had moderate dyspepsia, 42(15.8%) had mild dyspepsia, and 2(0.8%) very mild dyspepsia. In multiple linear regression models, dyspepsia as well as dyspepsia severity were significantly associated with patients' low quality of life QoL($P<0.001$).This study revealed a high burden of dyspepsia among medical outpatients as well as an association between dyspepsia, dyspepsia severity and patient QoL. We recommend screening for dyspepsia as well as widening the scope of investigation among a larger patients' population.*

***Keywords*** *Dyspepsia, Quality of Life, Risk Factors, Severity.*

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## Introduction

Dyspepsia which originates from a Greek word (Greek "dys" [bad], "pepsis" [digestion]) is used for a collection of symptoms localized by the patient to the epigastric region and the flanks. The symptoms are usually epigastric pain and burning (60 to 70%), bloating post meals (80%), early satiety (60 to 70%), upper abdominal (80%), nausea (60%), and vomiting (40%) [1].

There is a wide etiological spectrum of dyspepsia including functional dyspepsia, gastritis, gastric ulcer, gastric cancer, duodenitis, duodenal ulcer, duodenal cancer and gastro-duodenal polyps [2].

Globally the prevalence of dyspepsia varies from 7% to 45% and this may be due to geographical location as well as the definition criteria used [3]. Dyspeptic accounts for 2% to 5% of outpatient visits in primary care facilities and 20% to 40% of gastroenterology consultations [4]. Dyspepsia is much less in high income countries (10%) than low-and middle-income countries (37.9%) [5].

Dyspepsia can cause disturbances with sleep, employment, physical and social activities as well as consumption of regular meals and drinks. Consequently, dyspepsia is linked to significant impairment of health-related quality of life. Potential complications of organic dyspepsia (peptic ulcer disease, gastritis and esophagitis) can include upper GI bleeding, perforation, strictures and malignant transformation (gastric cancer) [6].

Established risk factors for dyspepsia include Helicobacter Pylori infection, non-steroidal anti-inflammatory drugs (NSAID) use, low socioeconomic status, excessive alcohol use, smoking, and female sex [7, 8].

Anecdotal evidences in urban sub-Saharan Africa reported that about 33% of patients presenting with dyspepsia have a history of long term NSAID use, and dyspepsia in the setting of NSAID use is associated with higher risk for peptic ulcer disease (PUD) [8]. Among other risk factors for dyspepsia, psychiatric disorders such as anxiety and depression have been implicated – with about 38% of dyspepsia patients having anxiety disorders, while depression was found in 16% [9].

In Sierra Leone, many clinicians believe that there is widespread use of over the counter (OTC) medications such as NSAIDS which is a major risk factor for dyspepsia and therefore bringing this out in a research work will provide patients the necessary information for prevention.

Dyspepsia poses a significant burden on health care budgets globally ranging from expensive investigations such as upper GI endoscopy to long term acid suppression medications. It also affects the work force productivity due to frequent days off by patients with dyspepsia. It affects individual's quality of life due to problems with sleep, social and physical activities as well as their eating patterns.

Dyspepsia accounts for a significant percentage of medical out-patient consultations as well as a very huge proportion of a gastroenterology clinic.

Currently there are no published data on the prevalence, severity as well as risk factors of dyspepsia in the Sierra Leonean population. This study was done to determine dyspepsia prevalence, severity and its impact on quality of life among medical out-patients in a tertiary hospital in Sierra Leone.

## Methods

### Study Design

This was an observational cross-sectional study on the prevalence and severity of dyspepsia with its effect on quality of life among medical out-patients at the 34 Military hospital – a tertiary hospital in Sierra Leone.

### Study Population

All medical outpatients at the 34 Military Hospital and who gave consent were included in the study.

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## Exclusion Criteria

Patients less than < 18 years as well as those patients who were unable to respond to the questionnaires were excluded from the study.

Patients with advanced comorbidity such as end-stage kidney disease on dialysis, Stroke patients with aphasia and/or decompensated heart failure patients with breathlessness were not included in the study.

## Sample Size

$$N = \frac{Z^2 Pq}{d^2}$$

where N is the minimum required sample size; Z is the standard normal deviate corresponding to a 95% confidence level (Z = 1.96); P is the prevalence taken from a similar study done in Rwanda by Bitwayiki et al., who reported a prevalence rate of 38.9% [10]; q = 1 - P; and d is the desired level of precision, set at 5% (d = 0.05).

$$N = \frac{1.96^2 \times (0.389 \times 0.611)}{0.05^2} = 365$$

After adjusting for an anticipated 10% non-response rate, the final minimum sample size was 401.

## Data Collection Procedure

A systematic sampling was used to recruit patients in which every 2nd patient that met the inclusion criteria was selected. A standardized questionnaire was used to collect information on socio-demographic, clinical details and selected risk factors about dyspepsia from the study patients (figure1). A Short-form of Leeds Dyspepsia Questionnaire SF-LDQ was used to assess symptoms and severity of dyspepsia. A total symptom frequency score of ≥ 4 out of 16 indicates dyspepsia. It also assesses the most bothersome symptoms (indigestion, heartburn, regurgitation and nausea in the last 2 months). SF-LDQ also has dyspepsia severity scores (very mild dyspepsia =4. mild dyspepsia = 5-8, moderate dyspepsia = 9-15 and severe dyspepsia = 16-32). The Short Form Nepean Dyspepsia Index (SF-NDI) was used to assess the impact of dyspepsia on participants quality of life. The SF-NDI assess 10 sub-domains with a 5 -point scale from 1 to 5 with a score range of 10 (lowest) and 50 (highest) A low or poor quality of life is associated with higher scores > 30 points and a good quality of life ≤30 points. A digital BP machine was used to measure blood pressure in mmHg, a standard digital weighing scale to measure weight in kilograms, and a stadiometer used to measure height in meters.

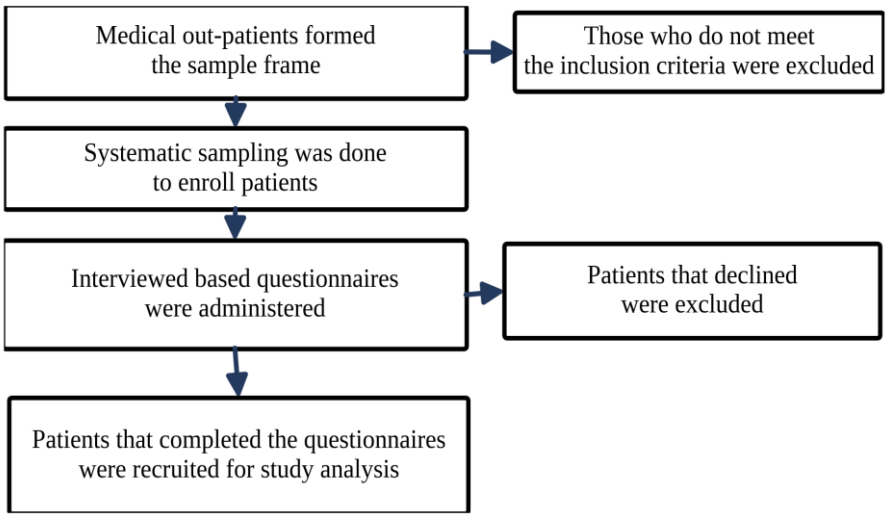


**Figure 1.** Participants Recruitment into the Study

## Data Analysis

Data was analyzed using the statistical package for social sciences (SPSS 28). Continuous variables were presented as mean ± standard deviation (SD). Categorical variables were measured in frequencies and percentages, and presented using bar and pie charts. Statistical associations were determine using logistics regression models such as: univariable and multivariable binary logistic regression, simple and multiple linear regression models, with a p- values < 0.05 considered statistically significant (α=0.05).

## Results

### Patients' Sociodemographic Information

A total of 401 patients were recruited into the study: 173(43.1%) males and 228(56.9%) females (Table 1). With regards the age bracket of the patients, 89(22.2%) were in the age bracket of 38 – 47 years, and only 24(6.0%) were in the age group of 68 – 77 years (Table 1). Out of the total participants, 167(41.6%) attained tertiary education, while 86(21.4%) never attended formal education (Table 1). Investigation of the marital status of the patients revealed that 247(61.6%) were married, while 125(31.2%) were single; 219(54.6%) were Muslims; and 219(54.6%) were employed (Table 1). With regards the income categories of the patients, 183(45.6%) had monthly income of >Le 500. 77(19.2%), and only 1(0.2%) earned Le 4000 - < 5000 (Figure 2).

**Table 1.** Patients' Sociodemographic Information

| Variable | Sub-variables | Frequency | Percent |
|---|---|---|---|
| **Gender** | Male | 173 | 43.1 |
| | Female | 228 | 56.9 |
| **Age groups** | 18 - 27 | 57 | 14.2 |
| | 28 - 37 | 111 | 27.7 |
| | 38 - 47 | 89 | 22.2 |
| | 48 - 57 | 80 | 20.0 |
| | 58 - 67 | 40 | 10.0 |
| | 68 - 77 | 24 | 6.0 |
| **Educational level** | None | 86 | 21.4 |
| | Primary | 28 | 7.0 |
| | Secondary | 120 | 29.9 |
| | Tertiary | 167 | 41.6 |
| **Marital status** | Single | 125 | 31.2 |
| | Married | 247 | 61.6 |
| | Separated/Divorced | 3 | 0.7 |
| | Widowed | 26 | 6.5 |
| **Religion** | Christian | 182 | 45.4 |
| | Muslim | 219 | 54.6 |
| **Employment status** | Employed | 219 | 54.6 |
| | Unemployed | 182 | 45.4 |

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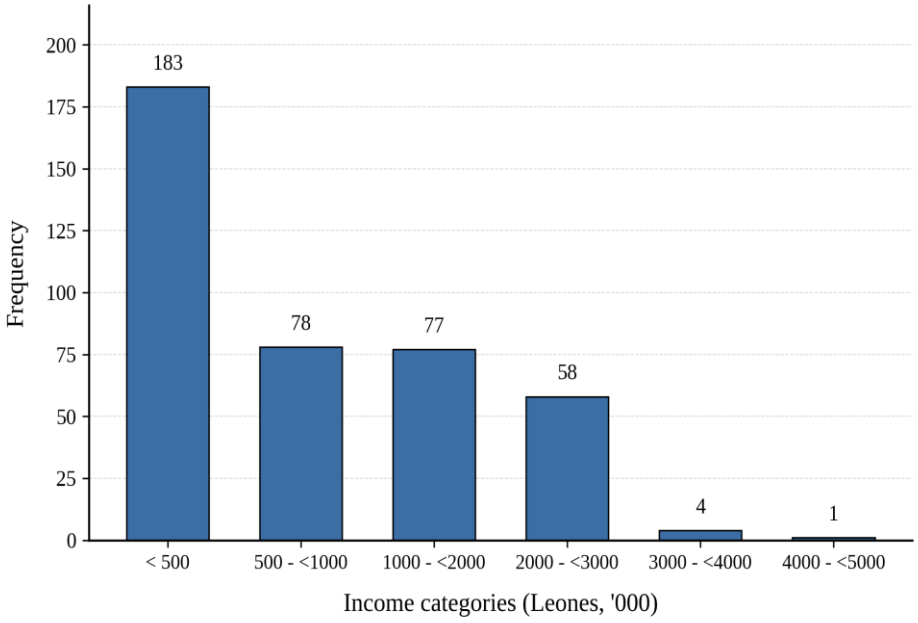


**Figure 2.** Distribution of Patients by Average Monthly Income Categories

## Patients' Clinical and Risk Factors Characteristics

Out of the 401 participants, 121(30.2%) were hypertensive; and 134(33.4%) were overweight (Table 2); 266 (66.3%) had dyspepsia (Figure 3); and among patients with dyspepsia 119(44.7%) severe dyspepsia (Figure 4). Analysis of the most troublesome dyspeptic symptoms reported by patients showed that 29(7.2%) had nausea, 72(18.0%) had heartburn, and 151(37.7%) had indigestion (Table 3).

Alcohol intake was done by 121 (30.2%) patients, and 44(11.0%) were cigarette smokers (Table 4). Regular use of NSAIDs was practiced by 82(20.4), 13(3.2) regularly used steroids, 65(16.2) regularly used kola nuts, 87(21.7) regularly use Nescafe, 176(43.9) regularly drink energy drinks, 216(53.9) regularly eat spicy food, and 210(52.4) regularly eat late meals (Table 5). Documented comorbidities revealed that 32 (8.0%) had diabetes, 20 (5%) had gall bladder stones, 14 (3.5%) had GI cancer while 12 (3.0%) had liver cirrhosis (Table 6).

**Table 2.** Summary of Patients' Clinical Characteristics

| Variables | Sub-variables | Frequency | Percent |
|---|---|---|---|
| **Hypertension** | Non-hypertensive | 280 | 69.8 |
| | Hypertensive | 121 | 30.2 |
| **BMI** | Under weight | 19 | 4.7 |
| | Normal | 156 | 38.9 |
| | Over weight | 134 | 33.4 |

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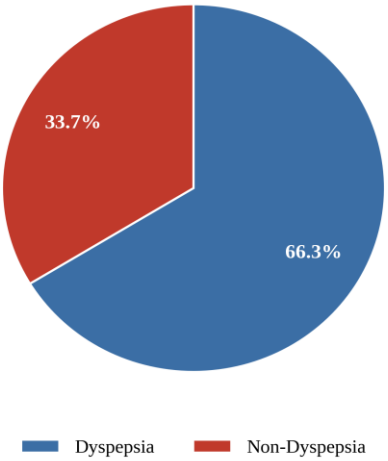


**Figure 3.** Distribution of Patients by Dyspeptic Categories

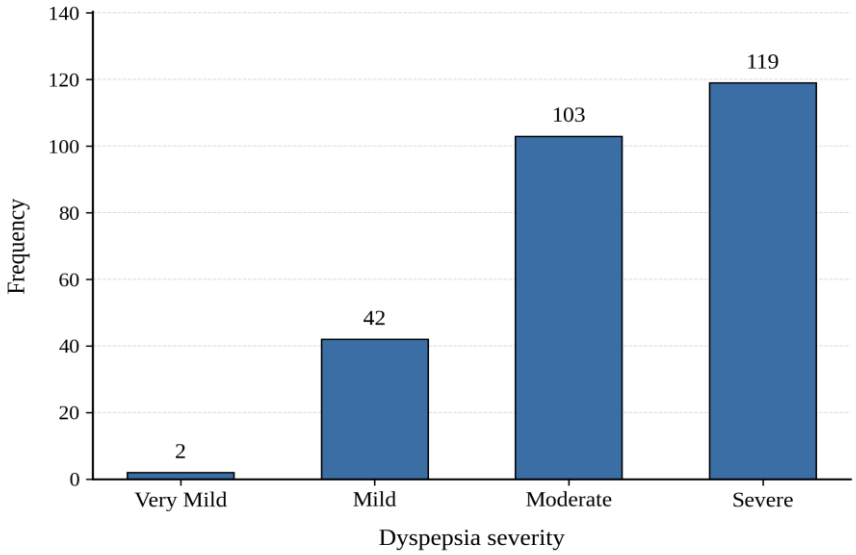


**Figure 4.** Severity of Dyspepsia among Dyspeptic Patients

**Table 3.** Synopsis of the Most Troublesome Dyspeptic Symptoms Reported by Patients

| **Symptoms** | **Frequency** | **Percent** | **Cumulative %** |
|---|---|---|---|
| Indigestion | 151 | 37.7 | 37.7 |
| Heartburn | 72 | 18.0 | 55.6 |
| Regurgitation | 23 | 5.7 | 61.3 |
| Nausea | 29 | 7.2 | 68.6 |
| None | 126 | 31.4 | 100.0 |
| **Total** | **401** | **100.0** | |

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**Table 4.** Patients Smoking and Alcohol Consumption Distribution

| Variables | Sub-variables | Frequency | Percent |
|---|---|---|---|
| **Alcohol intake (N=401)** | Yes | 121 | 30.2 |
| | No | 280 | 69.8 |
| **Types of alcohol (N=121)** | Beer and/or Stout | 78 | 64.5 |
| | Wine | 32 | 26.4 |
| | Liquor | 9 | 7.4 |
| | Local alcoholic drinks | 2 | 1.7 |
| **Qty. of beer/Stout (N=78)** | 1 drink daily | 24 | 30.8 |
| | 2-3 drinks daily | 43 | 55.1 |
| | >3 drinks daily | 11 | 14.1 |
| **Qty. of wine (N=32)** | 1 glass daily | 11 | 34.4 |
| | 2-3 glasses daily | 19 | 59.4 |
| | >3 glasses daily | 2 | 6.3 |
| **Qty. of liquor (N=9)** | 1 drink daily | 1 | 11.1 |
| | 2-3 drinks daily | 5 | 55.6 |
| | >3 drinks daily | 3 | 33.3 |
| **Qty. of local alcohol (N=2)** | 1 drink daily | 0 | 0.0 |
| | 2-3 drinks daily | 1 | 50.0 |
| | >3 drinks daily | 1 | 50.0 |
| **Cigarette smoking (N=401)** | Yes | 44 | 11.0 |
| | No | 357 | 89.0 |
| **Daily cigarette smoked (N=44)** | ≤ 5 Sticks daily | 37 | 84.1 |
| | > 5 Sticks daily | 7 | 15.9 |

**Table 5.** Presentation of Other Risk Factors of Dyspepsia

| Risk Factors of dyspepsia | Yes N(%) | No N(%) |
|---|---|---|
| Regular use NSAIDS | 82(20.4) | 319(79.6) |
| Regular use steroids | 13(3.2) | 388(96.8) |
| Regular use kola nut | 65(16.2) | 336(83.8) |
| Regular use Nescafe | 87(21.7) | 314(78.3) |
| Regular use energy drinks | 176(43.9) | 225(56.1) |
| Regular eating of spicy meals | 216(53.9) | 185(46.1) |
| Regular eating of late meals | 210(52.4) | 191(47.6) |

**Table 6.** Summary on Patients' Comorbidities

| Variables | Sub-variables | Frequency | Percent |
|---|---|---|---|
| **Diabetes** | Yes | 32 | 8.0 |
| | No | 369 | 92.0 |
| **Hyperthyroidism** | Yes | 4 | 1.0 |
| | No | 397 | 99.0 |
| **Hypothyroidism** | Yes | 2 | 0.5 |
| | No | 399 | 99.5 |

| | | | |
|---|---|---|---|
| **Chronic pancreatitis** | Yes | 5 | 1.2 |
| | No | 396 | 98.8 |
| **Gall stones** | Yes | 20 | 5.0 |
| | No | 381 | 95.0 |
| **Liver cirrhosis** | Yes | 12 | 3.0 |
| | No | 389 | 97.0 |
| **GI cancers*** | Yes | 14 | 3.5 |
| | No | 387 | 96.5 |

** GI cancers (Liver, pancreas, gall bladder, esophagus, stomach, colon). Gastric cancer =9, Pancreatic cancer =2, and Liver cancer =3*

## Summary of Patients' Quality of Life Information and Associated Factors

Out of the total patients, 286(71.3%) had good quality of life (SF-NDI scores ≤ 30) and 115(28.7%) had poor quality of life (SF-NDI Scores > 30) (Figure 5).

Using the patients' SF-NDI quality of life scores as dependent variable, we performed linear regression analyses. In both univarible and multiple linear regression models, patients' gender, age and employment status were not significantly associated with the patients' quality of life (all P-values > 0.05) (Table 7). However, the patients' dyspepsia scores and dyspepsia severity scores were significantly associated the quality of life in the univariable model ($P$<0.001), but in the multivariable model, only the dyspepsia severity scores were significantly associated quality of life ($P$<0.001), while the dyspepsia scores were not ($P$ = 0.094) (Table 7).

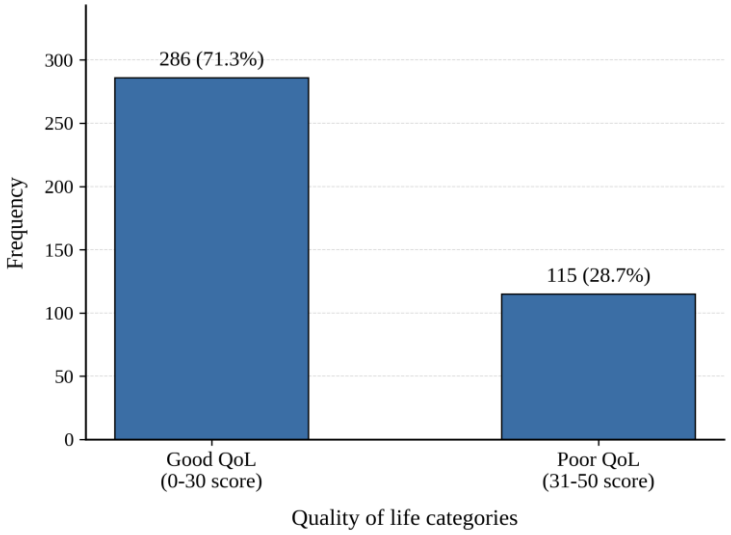


**Figure 5.** Distribution of Patients by Quality of Life Categories

**Table 7.** Association between Patients' Quality of Life and Dyspepsia

| **Variables** | **Beta** | **95% CI** | | **P-value** |
|---|---|---|---|---|
| | | **Lower** | **Upper** | |
| **Univariable model** | | | | |
| Gender | 0.039 | -1.251 | 2.927 | 0.431 |
| Age | 0.041 | -0.042 | 0.101 | 0.417 |
| Employment | -0.009 | -2.271 | 1.888 | 0.856 |

| | | | | |
|---|---|---|---|---|
| Dyspepsia scores | 0.659 | 1.237 | 1.550 | **<0.001** |
| Dyspepsia Severity scores | 0.671 | 0.635 | 0.790 | **<0.001** |
| **Multivariable model** | | | | |
| Gender | 0.043 | -0.658 | 2.492 | 0.253 |
| Age | 0.034 | -0.029 | 0.078 | 0.364 |
| Employment | 0.012 | -1.321 | 1.828 | 0.752 |
| Dyspepsia scores | 0.215 | -0.078 | 0.987 | 0.094 |
| Dyspepsia Severity scores | 0.465 | 0.227 | 0.762 | **<0.001** |

*CI = Confidence Interval. Bold figures represent statistically significant findings*

## Investigation of Risk Factors Associated with Dyspepsia

Using patients' dyspepsia status as dependent variable, we performed binary logistics regression analysis and our findings showed that in both the univariable and multivariable model, risk factors such as regular use of NSAIDs, steroids, kola nuts, Nescafe, energy drinks, spicy meals, late meals, alcohol, and cigarette smoking were not significantly associated with dyspepsia (all P-values >0.05) (Table 8).

**Table 8.** Summary of the Investigation of Risk Factors Associated with Dyspepsia

| **Variables** | ***OR*** | ***95% CI*** | | ***P*-value** |
|---|---|---|---|---|
| | | **Lower** | **Upper** | |
| **Univariable** | | | | |
| Regular use of NSAIDs | 1.615 | 0.936 | 2.789 | 0.085 |
| Regular use of steroids | 1.147 | 0.347 | 3.794 | 0.822 |
| Regular use of Kola nut | 1.679 | 0.915 | 3.082 | 0.094 |
| Regular use of Nescafe | 1.089 | 0.656 | 1.808 | 0.741 |
| Regular Use of energy drinks | 1.214 | 0.798 | 1.847 | 0.366 |
| Regular use of spicy meals | 1.130 | 0.746 | 1.711 | 0.565 |
| Regular use of late meals | 1.128 | 0.745 | 1.708 | 0.568 |
| Alcohol drinking | 1.291 | 0.815 | 2.046 | 0.276 |
| Cigarette smoking | 1.402 | 0.697 | 2.818 | 0.343 |
| **Multivariable** | | | | |
| Regular use of NSAIDs | 0.806 | 0.357 | 1.821 | 0.604 |
| Regular use of steroids | 1.323 | 0.243 | 7.196 | 0.746 |
| Regular use of Kola nut | 2.337 | 0.903 | 6.049 | 0.080 |
| Regular use of Nescafe | 0.933 | 0.417 | 2.089 | 0.866 |
| Regular Use of energy drinks | 1.237 | 0.553 | 2.766 | 0.604 |
| Regular use of spicy meals | 0.911 | 0.277 | 3.000 | 0.878 |
| Regular use of late meals | 0.838 | 0.258 | 2.724 | 0.768 |
| Alcohol drinking | 1.457 | 0.760 | 2.794 | 0.257 |
| Cigarette smoking | 2.164 | 0.829 | 5.650 | 0.115 |

## Discussion

This study investigated the prevalence and severity of dyspepsia, as well as its impact on quality of life (QoL), among medical outpatients at the 34 Military Hospital, a tertiary facility in Sierra Leone. The overall prevalence of dyspepsia was 66.3%. Among

dyspeptic patients, severity was classified as severe (44.7%), moderate (38.7%), mild (15.8%), and very mild (0.8%). Assessment of overall well-being revealed that 71.3% of patients experienced a good QoL, whereas 28.7% reported a poor QoL. Furthermore, statistical analysis demonstrated a highly significant correlation between increased dyspepsia severity and reduced QoL (\(p < 0.001\)). Notably, in both univariable and multivariable models, dyspepsia was not significantly associated with the regular use of NSAIDs, steroids, kola nuts, Nescafe, energy drinks, spicy meals, late meals, alcohol, or cigarette smoking (all $p > 0.05$).

From our study the prevalence of dyspepsia was 66.3% and majority had severe form of dyspepsia 44.7%. This prevalence is higher than that reported in a Rwandan study by Bitwayiki and team in 2015 in which they reported a prevalence of 38.9% and severe dyspepsia of 10.2%[10]. Although both studies utilized identical assessment tools—the Short-Form Leeds Dyspepsia Questionnaire (SF-LDQ) and the Short-Form Nepean Dyspepsia Index (SF-NDI)—the observed discrepancies in prevalence and severity may stem from differences in study populations and sampling techniques. Specifically, our study evaluated medical outpatients, whereas Bitwayiki et al. [10] primarily enrolled healthy healthcare workers. Notably, both studies demonstrated a significant association between dyspepsia and a reduced quality of life.

The prevalence of dyspepsia in this study was 66.3%, which is substantially higher than the 14.1% reported in a larger, population-based Rwandan study by Bangamwabo et al. in 2020 [11]. Although both studies utilized the Short-Form Leeds Dyspepsia Questionnaire (SF-LDQ), discrepancies in sample sizes, study populations, and methodologies likely account for this wide variation. Furthermore, both investigations identified a significant association between dyspepsia and a reduced quality of life, as measured by the Short-Form Nepean Dyspepsia Index (SF-NDI).

In the present study, 28.7% of patients experienced a reduced quality of life, compared to the 92.6% reported by Egbo et al. [12].This discrepancy likely stems from differences in the study populations; Egbo and colleagues evaluated known dyspeptic patients undergoing upper gastrointestinal endoscopy, who were inherently more likely to present with severe symptoms impacting their quality of life.

Our study also showed a higher prevalence of dyspepsia compare to that reported in a Ghanaian population-based study by Olecki et al in which they enrolled patients visitors and the prevalence was 25.5% [8]

Our study also revealed a higher dyspepsia prevalence of 66.3% using the Short Form Leeds Dyspepsia Questionnaire (SF-LDQ) in comparison to a study done in a referral hospital in Ethiopia by Seid et al. in 2018 in which they found out that 48.4% of patients had dyspepsia using the ROME III criteria [13]. This variation in prevalence may be related to the differences in dyspepsia questionnaires used as well as the sample sizes. Seid and team also reported that there was a statistically significant correlation between NSAIDs use ,regular intake of tea and dyspepsia ( p-values $< 0.001$) [13]. Our study found no statistical association between the use of alcohol, smoking, NSAIDs, Nescafe energy drinks and dyspepsia (p values $> 0.05$).

A lower prevalence of dyspepsia (44.7%) was reported in a study done in a Nigerian teaching hospital in 2011 by Efealukwu in which they also found a significant correlation between dyspepsia and coffee intake as well as alcohol intake (p values $< 0.001$) [14]. This dyspepsia prevalence as well as associated risks factors differs from that reported in our own study despite both are done within the sub-region with similar study settings.These variations are likely due to the distinct questionaire type in each study. In addition another Nigerian study done by , Ogunmodede et al, they also reported a lower dyspepsia

prevalence of 37.5% [15] compared to our study 66.5%. However both studies identified epigastric pain (indigestion) as the most frequent symptom of dyspepsia reported.

Two Asian studies revealed lower dyspepsia prevalence rates – Huang et al in Indonesia reported a prevalence of 49.75% using ROME III criteria for dyspepsia [16], while Khademolhosseini et al reported a prevalence of 29.9% using a gastroenterologist directed questionnaire [17].

In Zhejiang Province, China, Li and co-researchers reported a significantly lower dyspepsia prevalence of 5.6% using Rome III criteria among college students [18]. This heterogeneity in dyspepsia prevalence may stem from variations in sample sizes, diagnostic questionnaires, and study populations.

Sharma B et al also reported a lower dyspepsia prevalence of 39.3% [19] in a case-control Indian study in comparison to our study with a higher prevalence of 66.3%.

A lower prevalence of dyspepsia 14.6% was also reported in a Malaysian study by Mahadeva et al in which they also found an association between dyspepsia and poor quality of life [20]. The variations in the prevalence from our study could be due to the differences in dyspepsia screening questionaire.

In our study, the prevalence of dyspepsia (66.3%) closely mirrored the 66.1% reported in a Saudi Arabian cohort by Masoodi in 2018 [21]. Despite differences in study populations and sample sizes, both investigations utilized a cross-sectional observational framework and the SF-LDQ assessment tool. This methodological alignment likely accounts for the near-identical prevalence rates. Furthermore, Masoodi noted a significant association between NSAID consumption and dyspeptic symptoms ($p < 0.001$) [21].

However, in a second Saudi Arabian observational survey by Alwhaibi et al in 2020, a higher dyspepsia prevalence of 92% [22] was recorded, compared to 66.3% in our study. Furthermore, in a study conducted in the United Arab Emirates (UAE) by Jaber et al. in 2016, the reported dyspepsia prevalence was 43.8% using the Short-Form Leeds Dyspepsia Questionnaire (SF-LDQ) [23]. This variability in prevalence, despite the utilization of the same screening tool, could be attributed to the heterogeneity of the study populations as well as differences in sample sizes.

In Yemen, Al-Bishi, A. M. N reported a higher dyspepsia prevalence of 80% among outpatients in a gastroenterology clinic using Rome III criteria compare to our study 66.3%. Differences in dyspepsia screening questionaire and study population could account for these disparities [24].

In our study we found out a higher prevalence of dyspepsia (66.3%) compared to that reported in Latin America countries including Peru (27%), El Salvador (38%), Mexico (29%) and Colombia (37%). These differences could be explained by the differences in study population and sample sizes [25].

Our study reported a higher prevalence of dyspepsia in comparison to data from Western countries, including Sweden (20.2%) by Aro et al. in 2009 [26] and New Zealand (34.2%) by Haquel et al. in 2000 [27] . This variation may stem from a greater burden of Helicobacter pylori infection in developing countries relative to Western nations. Indeed, H. pylori plays a well-established role in the pathogenesis of both functional and organic dyspepsia.

## Conclusion

Our study revealed high burden of dyspepsia in our study population, with a dyspepsia prevalence of 66.3%. Poor Quality of Life was reported in 28.7% of the study patients while more than two-thirds reported good quality of life. The investigation further revealed a significant association between severity of dyspepsia and patients' Quality of Life ($p<0.001$). Patients demonstrated varying proportions of dyspepsia risk factors, with 30.2% of patients admitted consuming alcohol

while 11.0% were smokers. The study also showed that 53.9% consume regular spicy meals, 52.4% have regular late meals, 20.4% of patients do take regular NSAIDs, 43.9% consumed energy drinks and 21.7% take regular Nescafe use. However, despite the quality evidence provided in this research, we recommend a multi-center, larger sample size study to provide a more generalizable estimate of the true prevalence and burden of dyspepsia in Sierra Leone.

## Data Availability

The dataset analysed in this current study is available from the corresponding author upon reasonable request, subject to ethical approval and institutional data-sharing policies/agreements.

## Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or non-profit sectors.

## Conflict of Interest

The authors declare there are no conflicts of interest related to this study.

## Ethical Consideration

Study approval was obtained from the Texila American University TAU, Guyana in partnership with the University of Central Nicaragua UCN, Nicaragua. Ethical clearance was obtained from Sierra Leone Ethics and Scientific Review Committee (SLESRC No 011/02/2023). Permission was also obtained from the 34 Military Hospital administrations before study commencement.

The purpose of the study was explained to all the study participants and written informed consent was provided before recruitment into the study. Blood pressure results and severity of dyspepsia scores were communicated to the patients and attending physician for appropriate medical care. Patient confidentiality was maintained and questionnaires were coded. Patients were free to withdraw at any point in the study without any discrimination or loss of routine medical care.

## Author Contributions

- **Kanu Joseph E:** Design of study, data collection, major financing, read the drafts and made in-put. Corresponding author.
- **Sovula Haja S:** Data collection read through manuscript drafts and made in puts.
- **Kanu Joseph S:** Design of the study, assist in analysis of data , read through the drafts and made in puts.

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# Modeling Healthcare 4.0 Pathways to Effective and Efficient Universal Health Coverage for Neglected Tropical Diseases in Nigeria

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***Abstract*** *Healthcare 4.0 technologies are increasingly recognized for their potential to strengthen Universal Health Coverage (UHC), yet the mechanisms through which they influence UHC performance for Neglected Tropical Diseases (NTDs) in resource-constrained settings remain insufficiently modeled. This study develops and empirically tests a socio-technical framework linking Healthcare 4.0 enablers, contextual conditions, and two key UHC performance dimensions, effectiveness and efficiency, in Nigeria. Primary data were collected from 314 experts across NTD, UHC, and digital health domains. A sequential analytical approach was implemented, including Principal Components Analysis, Confirmatory Factor Analysis, and Structural Equation Modeling. The final model demonstrated strong fit (RMSEA = 0.028; SRMR = 0.043; CFI = 0.99; NNFI = 0.99; $\chi^2/df$ = 1.24), with all structural paths statistically significant ($p < 0.001$). Two distinct but complementary pathways were identified. Technologies that enable continuous data exchange, ongoing monitoring, and enhanced clinical care, such as cloud computing and the Internet of Things, show stronger associations with effectiveness. In contrast, governance-oriented and computational infrastructures, including blockchain systems and big data analytics, are more closely linked to efficiency. The strength of these relationships varies depending on institutional readiness and broader system alignment. Collectively, the findings position Healthcare 4.0 as an integrated system driver whose effects are pathway-specific and context-dependent. The study provides an empirically grounded basis for designing coordinated digital health strategies aimed at strengthening UHC for NTDs in resource-constrained settings.*

***Keywords*** *Digital Health Transformation, Healthcare 4.0, Neglected Tropical Diseases, Nigeria, Structural Equation Modeling, Universal Health Coverage.*

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## Introduction

Neglected Tropical Diseases (NTDs) remain a major public health concern in Nigeria, which carries the largest NTD burden in sub-Saharan Africa. An estimated 138 million people were at risk in 2024, reflecting the scale and persistence of these conditions across the country [1, 2, 28]. Although Nigeria has established policy frameworks for both NTD control and Universal Health Coverage (UHC), implementation continues to fall short [2, 28, 29]. Service delivery remains fragmented, monitoring systems are weak, and coordination across institutions is often inconsistent [2, 3]. These limitations point to structural challenges beyond resource constraints, including system integration, real-time visibility, and operational coherence.

Recent evidence from Africa indicates that substantial progress has been achieved through regional NTD control and elimination programs; however, persistent challenges related to surveillance, coordination, financing, and health-system integration continue to limit sustainable elimination efforts. Lessons from these programs emphasize the need for stronger digital infrastructure and integrated health-system approaches capable of supporting real-time monitoring, resource allocation, and programmatic decision-making [27].

Healthcare 4.0 has emerged as a potential pathway for addressing these systemic weaknesses. Built on the convergence of Industry 4.0 technologies with healthcare delivery, Healthcare 4.0 emphasizes interconnected, data-driven, and responsive systems [4]. Technologies such as the Internet of Things (IoT), blockchain, cloud computing, big data analytics, artificial intelligence, and body sensors offer new opportunities to strengthen surveillance and improve coordination across levels of care [5, 6, 16]. However, their application within UHC systems for NTDs remains limited, often confined to isolated initiatives rather than integrated strategies [7].

Much of the existing literature focuses on individual technologies or high-income contexts, with relatively limited attention to integrated frameworks suited to low- and middle-income countries [8, 9]. In addition, UHC performance is frequently treated as a single outcome, without distinguishing between effectiveness and efficiency or examining how contextual conditions shape technological impact [10]. This creates an important gap in understanding the mechanisms through which Healthcare 4.0 influences performance. Recent studies further emphasize that the transition toward Healthcare 4.0 requires not only technological adoption but also organizational transformation and workforce digital readiness [11]. The digital transformation of healthcare has accelerated globally, particularly following the COVID-19 pandemic, which highlighted the importance of connected, data-driven, and resilient health systems capable of supporting continuity of care and rapid decision-making [18]. At the same time, advances in artificial intelligence and human-machine collaboration are increasingly shaping the future of healthcare delivery, creating new opportunities for enhanced diagnostics, predictive analytics, and personalized care [19]. These developments further reinforce the strategic relevance of Healthcare 4.0 technologies for strengthening health-system performance and advancing UHC objectives. Recent African evidence has similarly highlighted the importance of integrated systems approaches for sustaining NTD elimination gains, particularly through improved surveillance, coordination mechanisms, and data-driven decision-making [27]. Despite these advances, empirical models linking Healthcare 4.0 technologies to UHC performance for NTDs remain scarce.

Drawing on Healthcare 4.0, UHC, and NTD literature [4-15], this study adopts a socio-technical perspective in which digital technologies operate within a broader system of institutional, regulatory, and socio-economic

interactions. Within this framework, Healthcare 4.0 is conceptualized as an integrated system driver, whose impact depends on alignment with contextual conditions and whose effects are expressed through distinct performance pathways.

### Research Objectives

The primary objective of this study is to model pathway relationships between Healthcare 4.0 enablers, contextual moderators, and UHC performance outcomes for NTDs in Nigeria. This objective reflects the need to examine Healthcare 4.0 not as isolated technological components, but as an integrated system operating within a broader socio-technical environment.

The specific objectives are to: (1) develop a socio-technical model specifying pathway linkages between Healthcare 4.0 technologies and UHC performance outcomes; (2) empirically estimate the pathways through which Healthcare 4.0 enablers influence effectiveness and efficiency of UHC for NTDs; (3) identify pathway-specific technological drivers associated with each performance dimension; (4) quantify the moderating effects of institutional readiness, policy and regulatory frameworks, socio-cultural acceptance, and economic capacity on these pathways; and (5) evaluate overall model fit and explanatory power using multivariate structural modeling techniques.

## Materials and Methods

### Research Paradigm and Design

The study was grounded in a positivist epistemological paradigm and followed a hypothetico-deductive approach within a quantitative design [14]. This orientation reflects the study's focus on testing predefined structural relationships among Healthcare 4.0 enablers, contextual moderators, and UHC performance outcomes. The choice of a quantitative framework was also shaped by the need for statistical precision, given the complexity of the constructs and the multivariate nature of the proposed model. The work forms part of a broader doctoral project in which the conceptual framework and structural pathways were developed and validated using LISREL-based analysis.

### Study Setting and Population

The research was conducted in Nigeria, the most populous country in Africa, comprising 36 states and the Federal Capital Territory [17]. The study population consisted of three expert groups aligned with the conceptual model. Group A included UHC and NTD specialists in Nigeria (n = 111), such as clinicians, public health professionals, government officials, and development partners. Group B comprised Healthcare 4.0 and IT specialists in Nigeria (n = 100), including digital health practitioners and blockchain experts. Group C consisted of international Healthcare 4.0 experts (n = 103), who provided broader perspectives. This combination of local and international expertise was intended to balance contextual knowledge with comparative insights.

### Sampling and Data Collection

A stratified purposive sampling strategy was used to ensure balanced representation across the three expert domains. Questionnaires were distributed to 375 eligible participants (125 per group), yielding 314 valid responses (response rate: 83.7%). The sample size exceeds recommended thresholds for Structural Equation Modeling (SEM), including minimum requirements for stable parameter estimation [15]. Data were collected using a structured questionnaire based on the conceptual framework, with items measured on a five-point Likert scale. A pilot test with 15 respondents was conducted to assess clarity and reliability, resulting in minor refinements to wording and structure. Ethical approval was obtained prior to data collection, and informed consent was secured from all participants. Participation was voluntary, and respondents

were assured that their identities would remain confidential.

## Analytical Procedure

The analysis followed a structured multivariate sequence consisting of five stages, designed to progressively refine and validate the underlying model.

**Stage 1: Descriptive Statistics:** Means, standard deviations, skewness, and kurtosis were computed to assess data distribution and sample characteristics. Values within acceptable thresholds (±1 for skewness; ±2 for kurtosis) indicated approximate normality.

**Stage 2: Principal Components Analysis (PCA):** PCA with Varimax rotation and Kaiser normalization was used to identify underlying factor structures. Factor loadings ≥ 0.40 were retained. PCA served as a dimensionality-reduction step prior to confirmatory modeling, helping clarify how variables clustered empirically before imposing the theoretical structure.

**Stage 3: Reliability Analysis:** Cronbach's Alpha coefficients were computed to assess internal consistency. Values ≥ 0.70 were considered acceptable, while values ≥ 0.60 were deemed adequate for exploratory constructs [15].

**Stage 4: Confirmatory Factor Analysis (CFA):** CFA was conducted to validate the measurement model. Model fit was evaluated using $\chi^2$/df, RMSEA, RMR, and SRMR. Convergent validity was assessed using standardized factor loadings (≥ 0.50) and Average Variance Extracted (AVE ≥ 0.50), while discriminant validity was assessed through inter-construct correlations.

**Stage 5: Structural Equation Modeling (SEM):** SEM was used to estimate structural path coefficients, T-values, and $R^2$ values, enabling explicit modeling of effectiveness and efficiency pathways and their interaction with contextual moderators. Both moderated and non-moderated models were estimated and compared. Model fit was evaluated using standard indices, including GFI, AGFI, NFI, NNFI, CFI, IFI, RFI, PNFI, and PGFI, with established thresholds applied (CFI/NNFI ≥ 0.90; RMSEA/SRMR ≤ 0.08) [15]. SEM was selected because it allows the simultaneous estimation of multiple relationships, which is essential for testing models. The use of multivariate structural modeling is consistent with methodological recommendations for analyzing complex socio-technical systems where multiple latent constructs interact simultaneously [25].

All analyses were conducted using SPSS for descriptive statistics, PCA, and reliability testing, and LISREL for CFA and SEM. Data screening and preparation were performed prior to analysis to ensure completeness and consistency.

## Common Method Bias

To assess potential common-method bias, Harman's single-factor test was performed. The results showed that no single factor accounted for the majority of the variance, indicating that common-method bias was not a significant concern. While this does not eliminate all potential bias, it provides reasonable assurance that the findings were not dominated by measurement artifacts.

# Results

## Sample Profile

The final sample consisted of 314 respondents, with balanced representation across the three expert groups: Group A (35.4%), Group B (31.8%), and Group C (32.8%). Professional experience ranged from 5 to more than 20 years, and no respondent reported fewer than 5 years of domain experience. Knowledge of Healthcare 4.0 was distributed across scope (24.2%), architecture (28.0%), implementation (23.9%), and operations (23.9%), with a similar pattern observed for NTD-related knowledge.

Comparative analysis showed no statistically significant differences in response patterns across the three groups ($p > 0.05$), suggesting that perspectives were broadly consistent despite differences in professional background.

## Descriptive Statistics

All 24 variables recorded mean scores clustered around 4.0 (High) on the five-point scale (range: 3.95–4.08). Standard deviations ranged from 0.733 to 0.802, indicating meaningful variability in expert perceptions. Skewness and kurtosis values fell within acceptable thresholds (±1 and ±2, respectively), confirming approximate normality. One-sample t-tests showed that all mean scores were significantly higher than the neutral midpoint (3.0) ($p < 0.001$), reflecting strong agreement among experts regarding the relevance of Healthcare 4.0 technologies within Nigeria's UHC context.

## Reliability Analysis Results

Cronbach's Alpha values were 0.756 for Group 1 (NTD/UHC variables), 0.742 for Group 2 (Healthcare 4.0 variables), and 0.649 for the moderator group. Although the moderator value is lower, it remains acceptable for exploratory research [15]. No item deletion improved reliability, indicating that all items contributed meaningfully to their respective constructs.

## PCA: Structural Differentiation of Effectiveness and Efficiency

PCA revealed a clear structural distinction between effectiveness and efficiency as two related but separate UHC performance dimensions. Governance-oriented variables, such as disease mapping, intervention monitoring, supply tracking, coverage expansion, institutional readiness, policy frameworks, and partnerships, loaded primarily onto the effectiveness factor. In contrast, data-intensive and computational variables, including big data, fog computing, fund utilization monitoring, insurance claims, socio-cultural acceptance, economic readiness, and blockchain, loaded onto the efficiency factor. This differentiation supports the idea that Healthcare 4.0 operates through multiple functional pathways rather than a single unified mechanism.

## Model Comparison: Moderated vs. Non-moderated

The non-moderated model produced a p-value of 0.158 (confidence = 84.15%), while the moderated model yielded a p-value of 0.010 (confidence = 98.95%). This indicates that contextual moderators significantly improved model performance. Fit indices for the moderated model were strong: $\chi^2/df = 1.24$, RMSEA = 0.028, RMR = 0.025, SRMR = 0.043, NNFI = 0.99, CFI = 0.99, IFI = 0.99, NFI = 0.94, GFI = 0.93, and AGFI = 0.92. These results confirm that the moderated model provides a more accurate representation of the underlying relationships.

## Structural Equation Modeling (SEM Results)

The structural relationships of the validated moderated model are presented in Figure 1.

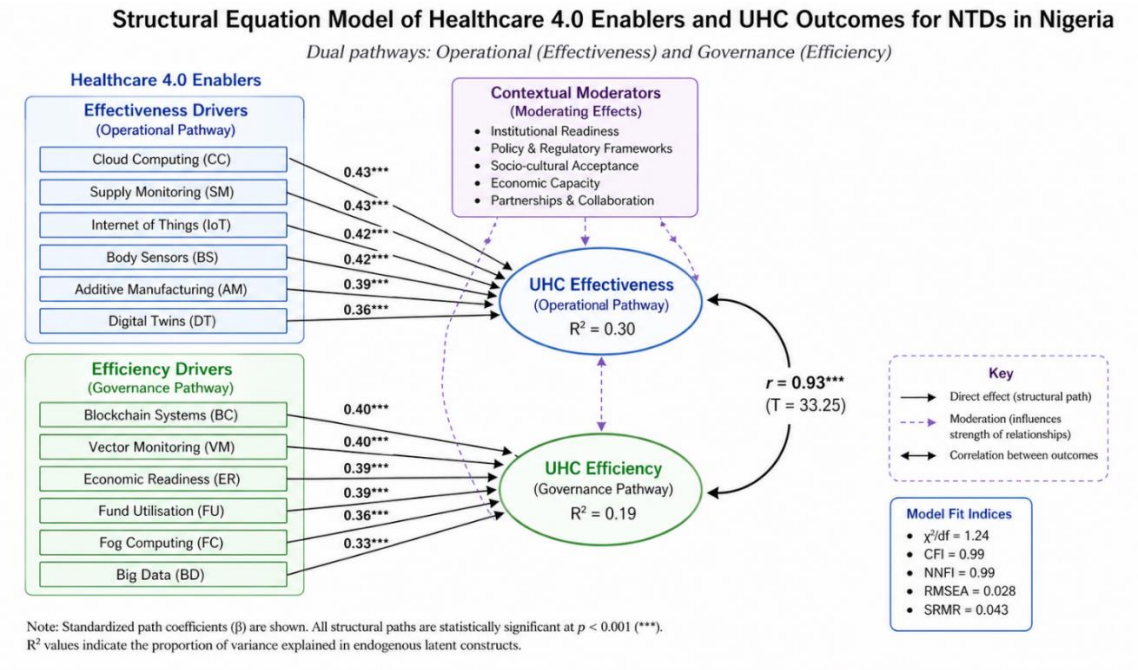


**Figure 1.** Structural Equation Model of Healthcare 4.0 and UHC Effectiveness and Efficiency for Neglected Tropical Diseases in Nigeria. Standardized path coefficients (β) are shown; all paths are statistically significant ($p < 0.001$)

*Source: Authors' conceptualization and empirical results derived from the doctoral study*

All hypothesized structural paths were statistically significant ($p < 0.001$). Technologies associated with continuous monitoring and data exchange, cloud computing (β = 0.43; T = 9.87), HIoT (β = 0.42; T = 9.53), and body sensors (β = 0.42; T = 9.61), showed the strongest positive effects on effectiveness. Governance-oriented and computational technologies demonstrated stronger effects on efficiency, with blockchain systems (β = 0.40; T = 9.56), vector monitoring (β = 0.40; T = 8.88), economic readiness (β = 0.39; T = 9.11), and fund utilization monitoring (β = 0.39; T = 9.00) emerging as the most influential predictors. These patterns reinforce the presence of two distinct but complementary pathways within the Healthcare 4.0–UHC relationship.

Contextual moderators, including institutional readiness, policy frameworks, socio-cultural acceptance, economic readiness, and partnerships, significantly strengthened the observed relationships, highlighting the importance of socio-technical alignment. The model explained a moderate proportion of variance in UHC performance ($R^2$ = 0.19–0.30), consistent with the complexity of health-system dynamics. A strong positive relationship was also observed between effectiveness and efficiency (r = 0.93; T = 33.25), indicating that improvements in one dimension tend to reinforce the other.

## Integrated SEM Results

Table 1 summarizes the pathway-specific technological effects across both UHC performance dimensions. All variables exerted statistically significant effects ($p < 0.001$), with varying magnitudes across pathways. The consistency of these results across constructs and pathways provides robust empirical support for the proposed socio-technical model.

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**Table 1.** Comprehensive SEM Results: Integrated Socio-technical Framework Linking Healthcare 4.0 to UHC Effectiveness and Efficiency for NTDs in Nigeria

| Variable | Outcome Dimension | β | T-value | $R^2$ |
|---|---|---|---|---|
| Cloud Computing (HCC) | Effectiveness | 0.43 | 9.87 | 0.30 |
| Supply Monitoring (DSCMSUP) | Effectiveness | 0.43 | 9.57 | 0.29 |
| HIoT (HIOT) | Effectiveness | 0.42 | 9.53 | 0.29 |
| Body Sensors (HBS) | Effectiveness | 0.42 | 9.61 | 0.29 |
| Partnerships (PCP4NTDN) | Effectiveness | 0.41 | 9.12 | 0.27 |
| Additive Manufacturing (HAM) | Effectiveness | 0.39 | 8.85 | 0.25 |
| Coverage Expansion (DSCMNOE) | Effectiveness | 0.38 | 8.58 | 0.24 |
| Institutional Readiness (RHPINH4) | Effectiveness | 0.37 | 8.60 | 0.24 |
| Intervention Monitoring (DSCMIPC) | Effectiveness | 0.37 | 8.64 | 0.24 |
| Policy Frameworks (HPRFN) | Effectiveness | 0.36 | 8.39 | 0.23 |
| Digital Twins (HDT) | Effectiveness | 0.36 | 8.23 | 0.22 |
| Disease Mapping (DSCMMD) | Effectiveness | 0.34 | 7.70 | 0.20 |
| Blockchain Systems (HBC) | Efficiency | 0.40 | 9.56 | 0.29 |
| Vector Monitoring (DSCMVS) | Efficiency | 0.40 | 8.88 | 0.26 |
| Economic Readiness (ERH4NTDN) | Efficiency | 0.39 | 9.11 | 0.27 |
| Fund Utilization (DSCMUFC) | Efficiency | 0.39 | 9.00 | 0.26 |
| Fog Computing (HFC) | Efficiency | 0.36 | 8.41 | 0.23 |
| R&D Monitoring (DSCMRDI) | Efficiency | 0.36 | 8.33 | 0.23 |
| Socio-Cultural Acceptance (SCAH4NTDN) | Efficiency | 0.36 | 8.10 | 0.22 |
| Insurance Claims (DSCMIC) | Efficiency | 0.36 | 8.10 | 0.22 |
| Intervention Processes (DSCMIP) | Efficiency | 0.34 | 8.07 | 0.22 |
| Big Data (HBD) | Efficiency | 0.33 | 7.53 | 0.19 |

*Note: β = standardized path coefficient; T-values > 1.96 indicate statistical significance at 95% confidence level; all paths significant at $p < 0.001$*

## Discussion

The findings provide strong empirical support for an interpretation of Healthcare 4.0 within UHC systems. Rather than producing uniform effects, the results indicate that different technological components operate through distinct functional pathways, each aligned with specific performance dimensions. This distinction is particularly important for understanding how digital health interventions translate into outcomes.

Technologies that support continuous data exchange, ongoing monitoring, and enhanced clinical care, particularly cloud computing, IoT, and body sensors, show stronger associations with effectiveness. This indicates that improvements in effectiveness are primarily driven by enhanced system coordination, real-time visibility, and responsiveness in service delivery. This aligns with prior evidence showing that real-time digital ecosystems significantly improve clinical responsiveness and care coordination in health systems [23].

In contrast, efficiency is more strongly influenced by governance-oriented and computational infrastructures, including blockchain systems, financial monitoring mechanisms, and big data platforms. These technologies contribute to improved transparency, accountability, and resource optimization, all of which are central to efficiency gains in UHC systems, particularly

within broader health-system reform efforts aimed at strengthening UHC in LMICs [20]. Similar studies have demonstrated that blockchain-enabled governance and big-data infrastructures enhance transparency and resource optimization in LMIC health systems [24].

When considered together, this pattern reinforces the view of Healthcare 4.0 as an integrated system driver rather than a collection of standalone technological solutions. The results suggest that outcomes depend not only on technological capabilities but also on their alignment with institutional structures and operational processes. This is consistent with sociotechnical systems theory, which emphasizes that digital transformation outcomes depend on alignment between technological, organizational, and human components [25].

The significant moderating effects further demonstrate that the impact of Healthcare 4.0 is contingent on contextual readiness, consistent with implementation research perspectives that emphasize the role of contextual and institutional factors in health system interventions [21]. Institutional capacity, regulatory frameworks, socio-cultural acceptance, and economic conditions shape both the strength and direction of technological influence. This highlights the importance of coordinated, system-wide alignment in achieving sustainable digital health transformation. Recent digital health transformation frameworks similarly highlight that system-wide alignment is essential for achieving sustainable UHC improvements in resource-constrained settings [26, 29].

These findings are consistent with recent evidence from African NTD elimination programs, which identified institutional coordination, monitoring capacity, stakeholder collaboration, and sustainable system integration as critical determinants of program success [27]. The present study extends this evidence by demonstrating how Healthcare 4.0 technologies can operationalize these requirements through pathway-specific mechanisms that strengthen both effectiveness and efficiency within UHC systems.

A key implication is that policy and implementation strategies should prioritize coordinated system design rather than isolated technology adoption to achieve meaningful and sustained improvements in UHC performance, particularly as digital health becomes increasingly central to UHC in resource-constrained settings [22].

## Contribution to Knowledge

This study advances the Healthcare 4.0 and UHC literature through four interrelated contributions.

First, it introduces an empirically validated dual-dimensional conceptualization of UHC performance (effectiveness and efficiency) for NTDs, thereby advancing the measurement of health-system outcomes beyond a single aggregated construct.

Second, it develops a context-sensitive socio-technical framework that links Healthcare 4.0 to UHC outcomes in LMIC settings, extending digital health theory to resource-constrained environments where constraints play a defining role.

Third, it provides an integrated multivariate validation of Healthcare 4.0–UHC relationships using Structural Equation Modeling, while empirically demonstrating the critical role of contextual moderators in shaping pathway-specific outcomes.

Fourth, it extends the NTD literature beyond predominantly clinical and intervention-focused perspectives by introducing a systems-level digital transformation paradigm for achieving UHC.

## Limitations and Future Research

This study has several limitations that should be considered when interpreting the findings. The cross-sectional design restricts the ability to draw firm causal conclusions about how

Healthcare 4.0 adoption influences UHC performance over time. The relationships observed here should therefore be viewed as indicative patterns rather than definitive evidence of temporal change. Longitudinal data would be needed to capture how these pathways evolve as technologies mature and institutional conditions shift.

The reliance on expert perceptions also introduces potential response bias. Although the sample included experienced professionals across NTD, UHC, and digital health domains, their assessments may not fully reflect operational realities in frontline settings. This is particularly relevant in contexts where digital health systems are still emerging, and expectations about technology may outpace implementation capacity. Purposive sampling further limits generalizability beyond the expert groups included in the study.

The moderate explanatory power of the model ($R^2 = 0.19–0.30$) reflects the complexity of health system performance, which is shaped by numerous structural, political, and contextual factors not captured by the current framework. Variables such as governance quality, policy enforcement, interoperability constraints, and informal system dynamics likely play important roles but were beyond the scope of this analysis.

Future research should incorporate longitudinal designs, mixed-methods approaches, and broader institutional variables to deepen understanding of how Healthcare 4.0 interacts with UHC systems in practice.

## Conclusion

This study provides empirical evidence on how Healthcare 4.0 technologies influence the effectiveness and efficiency of Universal Health Coverage (UHC) for Neglected Tropical Diseases (NTDs) in Nigeria. The results indicate that digital technologies do not operate in isolation; rather, their effects emerge through distinct but interrelated pathways shaped by contextual conditions. Technologies that support continuous data exchange and real-time monitoring are more strongly associated with effectiveness, while governance-oriented and computational infrastructures, such as blockchain systems and big data analytics, are more closely linked to efficiency.

These results highlight the importance of conceptualizing digital transformation as a process rather than a collection of discrete technological interventions. The strength and direction of these relationships are significantly influenced by contextual moderators, including institutional readiness, policy frameworks, socio-cultural acceptance, and economic capacity. The results highlight the need for alignment between technological capabilities and the broader institutional environment.

In settings such as Nigeria, where digital health initiatives often operate in fragmented silos, such alignment becomes essential for achieving meaningful and sustained improvements in UHC performance. The study contributes a validated socio-technical model that can inform policymakers, implementers, and development partners in designing more integrated and context-responsive digital health strategies for NTD control. The findings also support recent calls for integrated, technology-enabled approaches to NTD elimination in Africa that combine digital innovation with strong institutional and governance structures [27].

While the model explains a moderate proportion of variance, it provides a structured foundation for understanding how Healthcare 4.0 can support UHC goals in resource-constrained contexts. Overall, the findings suggest that digital technologies, when embedded within supportive governance and institutional systems, can play a central, enabling role in strengthening health-system performance and advancing progress toward UHC [29]. This reinforces the need to move beyond technology adoption toward digital integration in UHC policy design.

## Conflict of Interest

The authors declare no conflict of interest. This study was conducted as part of doctoral research at Texila American University, without financial or institutional bias.

## Ethical Approval

Ethical clearance was obtained from the Texila American University Institutional Review Board (IRB/TAU/2024/H4UHC/004), in compliance with the Declaration of Helsinki (2013). Informed consent was obtained from all 314 participants. Anonymity and data confidentiality were maintained throughout.

## Data Availability

Anonymized study-level data are available from the corresponding author upon reasonable request, subject to institutional approval. The theoretical framework and LISREL output are available as supplementary material.

## Author Contributions

- **YYI:** Conceptualization; theoretical framework development; data collection; formal analysis (PCA, CFA, SEM); writing original draft; review, and editing.
- **AOP**: Methodology supervision; critical appraisal of the analytical approach and findings; writing, review, and editing.
- **ALR**: Conceptual refinement; validation of analytical framework; critical review and editing of manuscript.

All authors have read and approved the final manuscript.

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# Critical Appraisal of Articles on Cross-Border Infrastructure Development in Africa

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***Abstract*** *Cross-border infrastructure development has become increasingly central to Africa's regional integration and economic transformation agenda, particularly under frameworks such as the African Continental Free Trade Area (AfCFTA), Agenda 2063, and the Program for Infrastructure Development in Africa (PIDA). This narrative review critically appraised existing literature on cross-border infrastructure development across Africa, focusing on transport corridors, energy networks, trade facilitation systems, financing models, governance structures, and socio-economic implications. The review revealed a broad consensus in the literature that regional infrastructure connectivity can reduce trade costs, improve market accessibility, stimulate industrialization, and strengthen intra-African cooperation. However, the literature remains fragmented across disciplines, regions, and methodological approaches. Existing studies are heavily concentrated in selected countries and sub-regions, while several parts of Central and West Africa remain underexplored. The review further identified an overemphasis on physical infrastructure development with comparatively limited attention given to soft infrastructure components such as institutional coordination, customs harmonization, border governance, and regulatory integration. Significant methodological weaknesses, theoretical inconsistencies, and limited post-implementation evaluations were also observed. In addition, emerging concerns regarding environmental sustainability, climate resilience, community displacement, and uneven socio-economic benefits remain insufficiently addressed in the current literature. Ultimately, the review demonstrates that while Africa has made considerable progress in expanding regional infrastructure networks, the translation of these investments into sustainable and inclusive outcomes of regional integration remains constrained by governance deficiencies, financing challenges, institutional fragmentation, and weak policy coordination. The study highlights the need for more interdisciplinary, context-sensitive, and empirically grounded research to address the complex realities of cross-border infrastructure development in Africa.*

***Keywords*** *Africa, Cross-border, Development, Infrastructure.*

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## Introduction

The pursuit of regional integration has increasingly become a central development strategy across Africa, particularly in response to the continent's long-standing infrastructural deficits, fragmented markets, and high trade transaction costs [1, 2] Over the past two decades, African governments and regional institutions have intensified efforts toward fostering economic cooperation and interconnected development through frameworks such as the African Union Agenda 2063 and the African Continental Free Trade Area (AfCFTA) [3, 4]. These continental initiatives are designed to promote economic transformation, industrialization, mobility, and sustainable development by enhancing regional connectivity and reducing barriers to intra-African trade [4]. Despite Africa's enormous resource endowment and growing population, intra-African trade remains comparatively low compared with other regions globally, largely due to inadequate and poorly interconnected infrastructure [2, 5]. Consequently, cross-border infrastructure development has emerged as a strategic mechanism for deepening regional integration and stimulating economic growth across the continent.

Cross-border infrastructure encompasses transnational transport corridors, railways, highways, energy transmission networks, pipelines, telecommunications systems, ports, and water resource projects that physically and economically connect two or more countries. Such infrastructure is widely recognized as a critical enabler of trade facilitation, market expansion, regional value chains, and socio-economic integration. Several scholars have argued that efficient regional infrastructure networks significantly reduce transportation and logistics costs, improve market accessibility, and enhance competitiveness within regional and global markets [6]. For instance, Calderón et al. emphasized that Africa's infrastructure gap substantially contributes to elevated trade and freight costs, thereby limiting productivity and economic integration across the continent [7]. Similarly, Fujimura highlighted that investments in regional transport and energy corridors can strengthen cross-border economic activities while fostering long-term regional cooperation [6]. These perspectives reinforce the growing consensus that infrastructure connectivity constitutes a foundational pillar for achieving the objectives of AfCFTA and broader continental development aspirations.

In recent years, scholarly interest in African cross-border infrastructure development has expanded considerably, producing a broad and multidisciplinary body of literature spanning economics, political science, development studies, engineering, geography, environmental studies, and international relations [8]. Existing studies have examined diverse themes, including transport corridor efficiency, financing mechanisms, public-private partnerships, geopolitical influences, governance structures, environmental sustainability, and the socio-economic implications of regional infrastructure projects [9]. Furthermore, significant attention has been devoted to major continental initiatives, including the Program for Infrastructure Development in Africa (PIDA), transnational railway systems, regional power pools, and strategic trade corridors linking African sub-regions [10]. Despite the increasing volume of publications, the literature remains highly fragmented in thematic orientation, methodological approaches, geographical coverage, and analytical depth [11].

A major challenge within the existing scholarship lies in navigating the dispersed and uneven nature of studies addressing African regional infrastructure networks [11]. While some articles focus predominantly on economic outcomes such as trade enhancement and growth stimulation, others emphasize governance challenges, political dynamics, environmental concerns, or

financing arrangements [9]. In many instances, studies are geographically concentrated in selected regions, such as East and Southern Africa, with comparatively limited attention to Central and parts of West Africa [12]. Moreover, variations in methodological rigor, conceptual frameworks, and empirical approaches have created inconsistencies in findings and interpretations across the literature. Consequently, there remains a need for a comprehensive appraisal that synthesizes and critically evaluates the existing body of knowledge to identify prevailing trends, scholarly strengths, conceptual limitations, and unresolved research gaps.

Against this backdrop, the present narrative review seeks to critically appraise the peer-reviewed literature on cross-border infrastructure development in Africa. Specifically, the review aims to evaluate the methodological approaches employed by scholars, examine the dominant thematic areas within the literature, assess the geographical distribution of existing studies, and identify systemic gaps that require further scholarly attention. By consolidating and critically interrogating existing research, this review aims to provide a clearer understanding of how cross-border infrastructure development has been conceptualized and analyzed in African scholarship, while also highlighting areas that require more robust empirical and theoretical exploration.

The scope of this appraisal is limited to scholarly publications and relevant institutional studies published from 2000 to the present, reflecting the period during which regional integration initiatives and continental infrastructure programs gained substantial momentum in Africa. The review specifically focuses on cross-border and transnational infrastructure assets, including transportation networks, energy systems, digital connectivity infrastructure, and transboundary resource projects that facilitate regional integration among African states. Domestic infrastructure projects lacking explicit regional or transnational dimensions are excluded from the appraisal. Through this delimitation, the review seeks to maintain analytical coherence while providing a focused examination of literature addressing infrastructure connectivity within the broader context of African regional integration and development.

## Methodology

This narrative review adopted a qualitative approach to evaluate existing literature on cross-border infrastructure development in Africa critically. Relevant studies published between 2000 and 2026 were identified through searches conducted using Google Scholar. Google Scholar was used to retrieve peer-reviewed journal articles and conference papers. The search strategy employed combinations of keywords and Boolean operators, including "cross-border infrastructure in Africa," "regional infrastructure development," "African transport corridors," "cross-border energy projects," "regional integration and infrastructure," "trade corridors in Africa," and "infrastructure financing in Africa." Reference lists of selected studies were also screened to identify additional relevant publications.

Included studies comprised peer-reviewed articles, policy papers, institutional reports, and conference publications focusing on regional transport, energy, ICT, or water infrastructure involving at least two African countries or regional blocs. Both qualitative and quantitative studies published in English were considered. Excluded studies included non-African infrastructure studies, publications lacking cross-border relevance, opinion articles, editorials, duplicate records, and studies without accessible full texts or clear methodological approaches. Selected studies were subsequently synthesized and critically appraised thematically according to major analytical dimensions within the literature.

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## Concept of Cross-Border Infrastructure

Cross-border infrastructure (CBI) represents a critical instrument for enhancing regional connectivity, economic integration, and intergovernmental cooperation across neighboring states. These projects typically involve the construction and coordination of physical infrastructure systems – such as highways, bridges, railways, pipelines, ports, and energy networks – that extend beyond national borders to facilitate the efficient movement of goods, services, capital, and people. Beyond their physical dimension, CBI projects are increasingly viewed as strategic mechanisms for advancing regional development, strengthening political cooperation, and promoting long-term stability among participating countries. Their implementation often demands extensive collaboration among governments, regional organizations, development finance institutions, private investors, and local communities, reflecting the multidimensional and transnational nature of such initiatives [13].

A major justification for the development of cross-border infrastructure lies in its potential to address infrastructural deficiencies and logistical bottlenecks that constrain trade and economic interactions between neighboring states. In many developing regions, inadequate transport and energy linkages continue to increase transaction costs and limit market accessibility. Consequently, governments and regional institutions invest in CBI projects to stimulate trade, attract investment, and deepen economic cooperation. Such initiatives also help reduce developmental disparities between neighboring regions by promoting more inclusive patterns of economic growth and shared prosperity [13].

Existing literature discussions on the prerequisites for successful CBI development further emphasize the importance of governance and institutional coordination. Studies by Fung, García-Herrero, and Ng [14], alongside the work of Van der Geest and Nunez-Ferrer [15], identified high-level government commitment as a central requirement for the successful implementation of cross-border projects. These studies also highlighted the beneficial role of neutral third-party actors, such as regional development banks and supranational institutions, in facilitating coordination and reducing political tensions among participating countries. Additionally, local stakeholder support was recognized as essential to the project's sustainability and legitimacy. However, these analyses paid limited attention to the geographical and spatial dimensions that influence the performance and effectiveness of CBI initiatives.

The concept of transport or economic corridors expands the understanding of cross-border infrastructure by incorporating both physical and functional dimensions. Physically, these corridors comprise interconnected transport routes linking strategic economic, political, and social centers across regions or countries. Functionally, they facilitate economic interaction by integrating transportation systems, trade logistics, and associated services into a unified framework. Such corridors typically include roads, railways, ports, airports, and logistics hubs designed to improve connectivity, reduce transportation costs, and accelerate the movement of goods and people. In this regard, transport corridors are increasingly regarded as catalysts for regional trade expansion, investment promotion, and economic transformation [16].

According to the African Development Bank, the developmental influence of corridors extends progressively over time. Initially, a transport corridor may primarily affect areas located immediately along its route. However, as complementary infrastructure – such as border posts, industrial parks, urban settlements, and logistics facilities – develops around the corridor, its

economic and social impact expands significantly. Economic activity begins to flow both into and out of the corridor, stimulating trade, urbanization, and broader regional development. This dynamic interaction ultimately enhances social and economic integration across participating regions [16].

Development corridors are therefore increasingly conceptualized as integrated spatial development frameworks that combine infrastructure investments with institutional coordination to stimulate regional growth and connectivity. Their effectiveness depends not only on transport infrastructure but also on efficient logistics and trade facilitation mechanisms, including customs administration, warehousing, and freight management systems. Furthermore, industrial clusters and economic hubs often emerge along these corridors, attracting investment, generating employment, and supporting manufacturing and commercial activities. Given their transnational nature, effective institutional and regulatory cooperation among participating states becomes indispensable for harmonizing policies, coordinating infrastructure development, and facilitating trade flows. Equally important is multimodal connectivity, which integrates road, rail, maritime, and air transport systems into cohesive networks that improve efficiency and reduce logistical constraints. Supporting services such as telecommunications, electricity, and water infrastructure also contribute to the sustainability of corridor development and the welfare of communities located along these routes [16].

A notable example of such a development corridor is the Ethiopia-Djibouti Corridor, which links landlocked Ethiopia to the Port of Djibouti. This corridor serves as a critical trade route supporting Ethiopia’s import and export activities through integrated road, railway, and port infrastructure systems. By improving logistics efficiency and reducing transportation costs, the corridor has become a strategic component of regional integration and economic development within the Horn of Africa.

Despite their developmental potential, cross-border and transport corridor projects continue to face significant structural and operational challenges. Regional political instability remains one of the most critical constraints, as conflicts and political unrest disrupt project continuity, discourage investment, and undermine long-term infrastructure planning [17]. Additionally, the underperformance or absence of efficient transport modes – particularly railway systems – has intensified dependence on road transport and private vehicle usage, thereby increasing congestion, accelerating infrastructure deterioration, and raising transportation costs for both passengers and freight [17].

Institutional inefficiencies further impede infrastructure development. Weak policy frameworks, inadequate planning processes, and ineffective project management frequently result in delayed implementation, resource misallocation, and poor prioritization of infrastructure needs. Financing also remains a persistent challenge, as both public and private investments are often insufficient to support the maintenance, expansion, and modernization of transport infrastructure. Consequently, deteriorating infrastructure systems struggle to meet increasing economic and demographic demands, thereby constraining regional growth and competitiveness [17].

Regulatory and institutional barriers equally contribute to escalating project costs and delays. Bureaucratic inefficiencies and weak governance structures often hinder the execution of capital budgets and limit governments' capacity to address infrastructure deficiencies effectively. Moreover, a substantial gap persists between the development of regional transport infrastructure and advances in human capital. The availability of skilled professionals

capable of managing, maintaining, and innovating transport systems remains essential for sustaining regional corridor initiatives and addressing emerging infrastructural challenges [17].

Overall, transport and economic corridors constitute fundamental drivers of regional integration, trade facilitation, and economic development. By improving connectivity and lowering transportation costs, these corridors stimulate investment, enhance economic competitiveness, and unlock regional productive capacities. Beyond economic gains, they also contribute to poverty reduction, employment generation, and inclusive development by strengthening economic linkages among participating countries. Importantly, such infrastructure networks are increasingly recognized as essential foundations for Africa's effective participation in global value chains and broader continental integration efforts [18].

## Evolution of Cross-Border Infrastructure Development in Africa

Cross-border infrastructure development in Africa has undergone significant transformation over the past two decades, evolving from fragmented national approaches to coordinated regional initiatives through major continental programs like PIDA and NEPAD. Akinleye (2026) provides the most comprehensive continental assessment, documenting remarkable achievements, including ICT infrastructure that exceeded targets by 150% and transport connectivity, delivering 16,066km of roads and 120 One Stop Border Posts across multiple countries [5]. However, this study reveals a critical disconnect between physical infrastructure and trade facilitation, with persistent high trade costs despite improved connectivity. Haruna (2025) offers valuable comparative insights through their analysis of East and Southern Africa, identifying transport, energy, telecommunications, and water as key integration sectors, highlighting institutional fragmentation and asymmetric connectivity as enduring challenges, and noting the evolution toward supranational coordination mechanisms drawn from Latin American experiences [19]. The energy sector has seen notable innovation, with Ikiomoworio (2021) documenting the emergence of Greenfield gas projects and cross-border energy collaboration as strategic priorities for regional security and sustainable development [20].

The financing landscape has diversified significantly beyond traditional development aid. Robert & Ombati (2023) analyze China's Belt and Road Initiative across five African countries, including Uganda, Kenya, Egypt, Djibouti, and Mozambique, revealing substantial infrastructure benefits alongside challenges, including procurement corruption, stakeholder exclusion, and increasing debt burdens [21]. Mathieu (2018) emphasizes the growing role of public-private partnerships, while noting that cross-border projects face heightened political risks and coordination complexities that require strong governmental backing and intergovernmental platforms for effective implementation [22]. Despite this progress, fundamental obstacles persist as established by Calderón & Serven (2008), who documented Sub-Saharan Africa's consistently poor infrastructure performance relative to other developing regions, findings that remain relevant today [23].

Contemporary challenges identified by Victor (2026) include limited private-sector participation at only 3% in PAP 1, low project bankability, with only 25% achieving feasibility, and inadequate institutional coordination, hampering policy harmonization [5]. Salum (2025) further highlights misaligned tariffs, rural infrastructure gaps, and ineffective policy coordination as persistent barriers that require adaptive frameworks grounded in African realities and South-South cooperation [24]. Recent innovations show promise, with the African

Development Bank pioneering integrated, multi-sectoral approaches and Gutman (2015) documenting the evolution toward innovative financing mechanisms that incorporate private capital. The reviewed multi-country studies demonstrate methodological diversity, from quantitative institutional analysis to qualitative comparative approaches, collectively revealing that while Africa has achieved significant physical connectivity improvements, translating infrastructure investments into economic integration outcomes remains challenging, requiring enhanced governance frameworks and stronger institutional coordination mechanisms to realize the full potential of cross-border infrastructure for regional development and trade facilitation [25].

## Beyond Concrete and Cables: The Critical Interplay of Hard and Soft Infrastructure in African Cross-Border Trade Facilitation

A critical appraisal of cross-border infrastructure in the African context reveals a fundamental truth that extends far beyond the traditional focus on physical structures: effective trade facilitation requires a sophisticated interplay between tangible assets and the institutional frameworks that govern their operation. The literature examining African trade dynamics demonstrates a clear dichotomy between "hard" and "soft" infrastructure, with mounting evidence from across the continent that their synergistic relationship ultimately determines trade performance outcomes and regional integration success.

The most comprehensive evidence on Africa comes from Tandrayen-Ragoobur (2022), who examined bilateral trade flows using a panel of 51 African countries from 2003 to 2015 [1]. Their infrastructure-augmented gravity model revealed that "both hard and soft infrastructures matter for trade in Africa," with particularly important findings regarding their relative importance. The study constructed separate indices for soft and hard infrastructure, as well as an effective infrastructure measure that combines both components, thereby providing robust empirical evidence of the continent's infrastructure-trade relationship.

Hard infrastructure's role in African trade facilitation shows distinct patterns that reflect the continent's development challenges and opportunities. Tandrayen-Ragoobur (2022) found that, when disaggregating hard infrastructure components, "the electricity composite index has a greater impact on trade flows relative to transport and ICT infrastructures," highlighting the critical bottleneck that unreliable energy systems pose for African trade [1]. This finding aligns with broader evidence from Portugal-Perez & Wilson (2012), whose analysis of developing countries demonstrated that "investment in physical infrastructure" significantly improves export performance, with particular relevance for African economies seeking to enhance their global trade integration [24].

However, the African experience reveals that physical infrastructure alone proves insufficient for optimal trade facilitation outcomes. Tandrayen-Ragoobur (2022) provided the most compelling African evidence that "soft infrastructure matters most and complements hard infrastructure in the region." This finding suggests that institutional frameworks may actually be the more decisive factor in determining whether African countries can translate infrastructure investments into meaningful trade gains. The study emphasized that "targeted policies and resources should be channeled towards improving energy infrastructure and soft infrastructure in terms of streamlining trading rules and procedures to propel better and maximize the benefits of intra-African trade."

Concrete evidence of the critical importance of soft infrastructure emerges from regional studies in specific African contexts. Zimano &

Ruffin (2018) examined four road entry points to Zimbabwe's territorial borders within the Southern African Development Community (SADC), surveying 345 participants, including truck drivers and small and medium entrepreneurs [26]. Their findings traced the perpetuation of delays specifically to "failure to tie together hard and soft infrastructure components of entry point management systems," which "consequently disturbs the supply chain of goods in the Southern African development community." This empirical evidence demonstrates how the disconnection between physical infrastructure and institutional systems creates tangible barriers to regional trade integration.

The complementary relationship between hard and soft infrastructure proves particularly crucial in the African context, where resource constraints make optimal utilization of existing investments essential. Maurel (2016) found that "a huge part of the missing bilateral trade fixed effect of North African countries is accounted for by soft and hard infrastructure," suggesting that addressing both dimensions simultaneously could unlock significant untapped trade potential across the continent [27]. Kingombe (2014) contributed to this understanding through a focused analysis of African infrastructure development patterns, though the specific findings require deeper examination to fully grasp the continent's unique challenges [28].

The African evidence consistently demonstrates that effective cross-border infrastructure requires coordinated development of both physical systems and institutional frameworks. Zimano & Ruffin (2018) emphasized "the importance of marrying hard and soft infrastructure for optimum efficiency," with their SADC analysis showing that supply chain performance depends critically on this integration [26]. The study's recommendations focused on how "road entry point management systems can be improved, in order to enhance regional integration," providing actionable insights for African policymakers.

Despite robust evidence from Africa on hard-soft infrastructure complementarity, significant gaps remain in the understanding of specific institutional mechanisms and political economy dynamics across the continent. The available sources lack detailed analysis of the implementation of One-Stop Border Posts (OSBPs) across African borders, comprehensive customs harmonization strategies within regional economic communities, and systematic approaches to reducing non-tariff barriers that particularly affect intra-African trade. More critically, the political economy dimensions examining how national sovereignty concerns conflict with continental infrastructure mandates under initiatives like the African Continental Free Trade Area remain largely unaddressed in the current literature.

The accumulated African evidence overwhelmingly supports the conclusion that effective cross-border infrastructure requires simultaneous and coordinated investment in both physical systems and institutional frameworks, with Tandrayen-Ragoobur (2022) providing definitive evidence that soft infrastructure serves as the critical enabler determining whether hard infrastructure investments translate into meaningful improvements in intra-African trade facilitation and continental integration outcomes [1].

## Critical Appraisal of Analytical Dimensions in African Cross-Border Infrastructure Research: Assessing Methodological Approaches to Financing, Socio-economic, and Environmental Impact Analysis

The critical appraisal of analytical dimensions in African cross-border infrastructure research reveals significant methodological gaps and uneven scholarly attention across financing, socio-economic,

and environmental domains. Current literature demonstrates substantial analytical limitations that constrain comprehensive understanding of project impacts and operational realities.

Regarding financing and investment models, the literature shows mixed analytical depth. Handayani (2025) synthesized empirical and theoretical studies (PPPs), finding that governance frameworks are critical to success, though developing countries face equity challenges when profitability takes precedence over social outcomes [29]. Besaiso (2025) analyzed 618 peer-reviewed articles (1999-2023), identifying governance and management as dominant themes but noting "limited integration of environmental and social dimensions" and "thematic fragmentation." [30] The role of external actors receives attention through BRI scholarship [31] though evidence "does not clearly favor one model over another in terms of achieving welfare-enhancing outcomes" [31]. Gutman (2015) examined three major external financing sources for African infrastructure but highlighted challenges in compiling comparable financing data, indicating persistent analytical gaps in understanding financing flows and their effectiveness [25].

Socio-economic and welfare impact analysis remains underdeveloped. Quium (2019) found transport infrastructure can positively impact growth and poverty, but cautioned that "distribution of impacts can be uneven" and "there can be important trade-offs between economy and welfare and environmental quality [32]." Idu (2025) identified opportunities for poverty alleviation through regional energy integration but noted persistent challenges in "regulatory harmonization, financing, and institutional capacity." [33] However, the literature lacks specific empirical evidence on gendered impacts and informal cross-border trade interactions with formal infrastructure, representing significant analytical blind spots.

Integration of environmental and climate resilience shows the weakest analytical development. Handayani (2025) noted environmental sustainability is "increasingly embedded" in PPP projects, but "integration remains uneven across regions." [29] Clark (2018) highlighted the disconnection between available climate finance and actual sustainable development investment, noting "fragmented and often sectoral" approaches [34]. Akram (2024) acknowledged environmental challenges in BRI projects but offered limited analytical frameworks for integrating climate adaptation [35]. The literature lacks systematic approaches to integrating climate change adaptation into cross-border project planning, with minimal evidence on decarbonized pathways or resilient design methodologies.

Overall, researchers have approached these projects through fragmented analytical lenses, with financing models receiving the most scholarly attention while environmental integration remains critically under-examined. The analytical dimensions reveal a field requiring more comprehensive, integrated methodological approaches that simultaneously address economic, social, and environmental outcomes.

## Methodological Deficiencies and Theoretical Misalignments: A Critical Assessment of Structural Flaws in African Infrastructure Research

The existing literature on African infrastructure development reveals many structural flaws that undermine the field's analytical rigor and policy relevance, beginning with stark geographical imbalances where Van Zyl (2026) found research concentrated more in just five countries – Nigeria, Ethiopia, Tanzania, South Africa, and Kenya – despite covering 27 African countries, with studies "fragmented across 51 journals" and characterized by "loosely connected author networks" that limit Africa-

specific conceptualizations [12]. This geographical bias is compounded by a troubling colonial legacy in authorship patterns, as Gregory and Sovacool (2019) discovered that "authors at institutions in Europe and North America accounted for a sobering 59% of the sample, with Africa (as a whole) only at 27%" in their systematic review of 101 studies, suggesting much work is "perhaps desk based and/or done at institutions with vested interests in the region (shaped by patterns of colonialism and imperialism)" [36]. Methodologically, the field suffers from what can only be described as academic negligence, with Gregory and Sovacool (2019) finding that "while the most popular utilized method among all articles examined was a qualitative geographic case study, the second most dominant method was none at all – studies that had no detectable research design or methods section," while only about 5% utilized "human centered, original data collection methods such as interviews, surveys, or experiments." These methodological shortcomings are further complicated by fundamental econometric challenges identified by Straub (2011) who noted that "despite all this accumulated evidence, the link between infrastructure availability and economic productivity or growth is still subject to considerable uncertainty and debate" due to endogeneity problems, measurement errors, and inadequate treatment of reverse causality [37].

The theoretical foundations prove equally problematic, as Stein and Nissanke (1999) argue that "neo-classical economic micro-foundations, associated intermediate propositions and theories underlying adjustment seriously mis-specify the nature of African economies" [38], while Ayogu (1970) observed that "considerable resources have been expended in the pursuit of this marginally important issue" of whether infrastructure matters, when "the crucial issue – understanding policymaking processes in infrastructure – remains little understood and largely under-researched" [39]. However, emerging literature suggests potential pathways forward, with Müller-Mahn (2020) calling for "post- and de-colonial positions and 'theory from the south'" and Lottu (2024) emphasizing "context-specific strategies" and "adaptable frameworks that address regional challenges and opportunities" [40].

## Conclusion

Cross-border infrastructure development remains an essential driver of regional integration, trade expansion, and economic transformation across Africa. The reviewed literature demonstrates that transport corridors, regional energy systems, and integrated logistics networks possess significant potential to enhance connectivity and support continental development goals. However, the existing literature remains fragmented, geographically imbalanced, and overly focused on physical infrastructure, often overlooking the critical roles of governance, institutional coordination, and soft infrastructure systems. Persistent challenges relating to financing, policy harmonization, environmental sustainability, and community-level impacts continue to limit the effectiveness of many projects. Consequently, achieving meaningful and inclusive regional integration will require stronger governance frameworks, improved institutional collaboration, and more context-specific, empirically rigorous research to address Africa's complex infrastructural realities.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

## Ethical Approval

Ethical Approval does not apply to this paper.

## Data Availability

Not Applicable.

## Author Contributions

Afolabi O. M. conceptualized this study, Finbarr J.Z. and Olufunto O.A. critically revised and corrected the manuscript for important intellectual content and supervised the study. Afolabi O.M. and Olufunto O.A conceived and drafted the review outline and contributed to manuscript writing. Afolabi O.M., Finbarr J.Z., Olufunto O.A, and Muhammed M.N. participated in the literature review and contributed significantly to writing and revising the manuscript. All authors read and approved the final version of the manuscript.

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# Navigating the Localization Dilemma: Institutional and Capacity Constraints within South Sudanese Non-Governmental Organizations and Private Enterprises

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***Abstract*** *The debate over localization who leads humanitarian work, and on whose terms has grown more contentious even as its rhetoric has grown more consensual. In South Sudan, where decades of armed conflict have left the state unable to deliver basic services and where international agencies control the bulk of humanitarian funding, the localization agenda collides daily with hard institutional realities. This paper examines those collisions directly, treating localization not as a settled good whose implementation merely requires political will, but as a contested process shaped by funding asymmetries, governance gaps, and the legitimate yet often competing interests of local organizations, international NGOs, and the communities they both claim to serve. The study draws on case evidence from Juba, Wau, Bor, Pibor, Malakal, and Bentiu to trace how localization actually unfolds on the ground where it works, where it stalls, and why. The central argument is straightforward: localization in South Sudan will not advance through declarations or Grand Bargain commitments alone. It demands structural changes in the funding architecture, a reduction in the compliance burdens that keep local organizations dependent on international intermediaries, and deliberate investment in local institutional capacity measured in years, not project cycles.*

***Keywords*** *Institutional and Capacity Constraints, Localization Dilemma, Non-Governmental Organizations, Private Enterprises, South Sudanese.*

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## Introduction

Localization, stripped of its jargon, refers to a rebalancing of power within humanitarian systems, a deliberate shift of resources, authority, and decision-making toward the communities and organizations closest to a given crisis. The principle is not new. It appears, in various guises, in the Paris Declaration on Aid Effectiveness, 2005, the Busan Partnership, 2011, and most prominently in recent years in the 2016 Grand Bargain, which committed major donors and UN agencies to channeling at least 25 percent of humanitarian funding directly to local actors by 2020 [9-11]. That target was missed. By most estimates, direct funding to local organizations still hovers around 2 percent of the global total. South Sudan illustrates why. The country has been in various states of war since its independence in 2011. By 2024, roughly 9 million people, over two-thirds of the population, will require some form of humanitarian assistance. The aid architecture that has emerged to meet this need is heavily international: UNMISS, OCHA, WFP, UNICEF, and a constellation of large international NGOs manage the vast majority of programming and control access to donor funding. Local organizations operate largely as subcontractors. They deliver services; they rarely design them.

This matters because the gap between what international frameworks prescribe and what South Sudanese communities actually need can be substantial. The South Sudanese conflict is not one conflict but many intercommunal disputes over land and cattle in Jonglei, factional fighting along ethnic lines in Upper Nile, and governance contestation in Central Equatoria. No single programmatic template fits all of these contexts. Local organizations, embedded in specific communities and accountable to specific constituencies, are often better positioned to identify what is needed and what will be accepted. The question the localization agenda raises is whether the current system is structured to allow them to act on that knowledge.

The early evidence from South Sudan is mixed. Where local organizations have been given genuine operational authority in Pibor, where the South Sudanese Development Organization used customary elders in dispute mediation, and where the Women Solidarity Group built financial management skills among women entrepreneurs, the results have been durable and contextually appropriate. Where localization has meant little more than subcontracting local NGOs to implement externally designed projects, the results have been modest. The difference between these two cases is not effort. It is the distribution of institutional power [4] has documented how women-led groups across South Sudan have played decisive roles in peacebuilding and environmental management roles that international frameworks often fail to recognize or resource adequately. The Overseas Development Institute has made a similar argument at the systemic level: genuine localization is not a logistical adjustment. It is a political one, requiring international actors to cede decision-making authority they have accumulated over decades. In South Sudan, where international presence is deep and local institutional capacity is thin, that cession is neither simple nor risk-free. But the evidence suggests it is necessary.

In Juba, several NGOs including the South Sudan Red Cross have worked to localise their operations by training local staff in disaster response and first aid. In Bentiu, CARE International has supported women-led farming cooperatives, helping local women rebuild livelihoods disrupted by conflict. In Wau, the Relief and Rehabilitation Commission has partnered with international organizations to streamline aid delivery, though capacity gaps and competing political interests continue to constrain progress. The Overseas Development Institute reports that only about 2 percent of international humanitarian assistance reaches

local actors directly, despite their central role in frontline crisis response. That imbalance is the single most important structural barrier the localization agenda must address.

## Overview of Localization in the Context of South Sudan's Development Challenges

Localization in South Sudan is a response to real, documented failures of externally led humanitarian programming, not a theoretical ideal. It centres local actors' community leaders, grassroots organizations, and the people themselves in the design and implementation of development initiatives tailored to the country's unique socio-political context. South Sudan's considerable agricultural potential stands in stark contrast to the food insecurity affecting the majority of its population, a gap that reflects how far development priorities have drifted from local realities toward externally determined frameworks. Adaptive approaches that genuinely integrate local knowledge into program design rather than treating it as supplementary to externally developed models consistently produce more relevant and durable outcomes than those designed from outside the affected context. International actors often operate within rigid frameworks that do not account for the fluid and dynamic nature of local challenges. Successful localization depends on forging stronger connections between external interventions and indigenous practices rather than treating the two as separate or competing. The principle of shifting power toward local actors, transferring not only resources but real decision-making authority, has become a rallying point in contemporary localization discourse for good reason: the evidence from South Sudan and comparable post-conflict settings consistently shows that when it actually happens, rather than being merely declared, the results are better.

## The Role of NGOs and Local Actors

Several international and local organizations have taken important steps to advance localization in South Sudan, amplifying local voices and transferring greater authority to local actors. Tearfund has implemented projects in Torit and Kapoeta that prioritize water, sanitation, and hygiene (WASH) services. By training local communities to manage water resources and maintain facilities, Tearfund enables them to take charge of critical infrastructure. CARE International has partnered with local women's groups in Malakal to establish small-scale agricultural cooperatives, positioning women as agents of change rather than aid recipients.

Power imbalances between international NGOs and local organizations are structural, not incidental, and they are replicated at every level of the system. The South Sudan Joint Response (SSJR), a coalition of NGOs funded by the Dutch Relief Alliance in Juba, has been a significant vehicle for localization. By incorporating the expertise of local NGOs such as the Coalition for Humanity, the SSJR ensures that humanitarian aid aligns with the cultural and social realities of South Sudanese communities. However, local NGOs often lack the financial resources, infrastructure, and political leverage to take genuine charge of development projects. As a result, localization can become tokenistic, with international organizations retaining decision-making power while local partners bear the responsibility for implementation. The Overseas Development Institute has stressed that effective localization cannot rest on rhetorical commitments; it demands a verifiable transfer of power, resources, and accountability to local actors, not a nominal shift in branding. In Juba, Help a Child and Save the Children have integrated local languages and cultural practices into education programs, increasing enrolment rates and improving learning outcomes. In Malakal, Norwegian Church Aid has leveraged the trust

and influence of local faith institutions to deliver psychosocial support that achieves higher levels of community engagement than comparable programs delivered through unfamiliar channels. The evidence from Wau, Malakal, and Bentiu points consistently in the same direction: programs genuinely rooted in local knowledge and led by community members generate stronger accountability, greater cultural relevance, and more durable outcomes than those designed externally.

## The Concept of Localization

Localization is sometimes described as though its meaning were self-evident. It is not. In practice, the term covers at least three distinct things: a funding shift (directing money to local actors rather than international intermediaries), a governance shift (giving local actors real authority over program design and implementation), and a cultural shift (treating local knowledge as analytically significant rather than decoratively included). These three dimensions do not always move together. A donor can increase the percentage of funding that nominally reaches local organizations while simultaneously requiring those organizations to comply with reporting frameworks, procurement rules, and project logics designed by and for international agencies. In such cases, the funding shifts; the governance does not. This distinction matters enormously for South Sudan. The Intergovernmental Authority on Development has sought to bring local actors into peace processes, and organizations such as the South Sudan Council of Churches have used interfaith dialogue and elder-led reconciliation to reduce intercommunal tensions in ways that external mediators could not replicate. Yet the SSCC operates on a fraction of the budget available to international peace organizations working on the same issues. The asymmetry is not incidental. It reflects a structural preference among donors, UN agencies, and large INGOs alike for partners whose accountability systems and reporting capacities they already understand.

In Boma National Park, ecotourism initiatives have created local employment and reduced dependence on subsistence farming, linking economic incentives to conservation goals that external models rarely achieve. In Bor and Pibor, traditional chiefs who have been incorporated into peacebuilding dialogues have produced measurable reductions in cattle-raiding tensions. These are not isolated successes. They are evidence that local knowledge, when given institutional space, produces outcomes that generic international programming cannot. But the same cases also expose localization's limits: ecotourism in Boma depends on tourist flows that are interrupted by conflicts, and community-led water projects have stalled when spare parts became unavailable, and no supply chain existed to provide them. Localization does not eliminate these problems. What it can do if structured seriously is build the local institutional capacity to address them over time, rather than cycling through internationally managed crises indefinitely.

## Women's and Youth Groups

Women's groups and youth organizations are not peripheral to localization in South Sudan. They are often its most effective practitioners. In Bentiu, youth-led initiatives have taken the lead in promoting education and vocational training among displaced populations providing practical skills while giving young people a stake in rebuilding their communities. These are not peripheral programs; they address the social fractures that conflict leaves behind. UN Women has consistently documented that women play decisive roles in conflict prevention, peacebuilding, and post-conflict recovery, yet their voices remain systematically marginalised within formal peace processes. In cities like Juba, local women's organizations have independently established healthcare, education, and support services for displaced

populations. Their involvement in the humanitarian response has produced programs more accurately calibrated to the needs of women and children than those designed without their input. The Humanitarian Accountability Partnership has documented that localization improves aid quality by making programs more culturally appropriate, contextually grounded, and genuinely responsive to the priorities and outcomes of affected communities, which is particularly important in South Sudan, where mistrust of international organizations runs deep, and community acceptance cannot be assumed.

## The Benefits of Localization

The empirical case for localization is strongest where it has been most honestly tested, where local actors have been given real authority rather than nominal inclusion. Three benefits stand out in the evidence from South Sudan. The first is contextual accuracy. International organizations designing programs from Nairobi or Geneva routinely miss important local variables, such as the significance of specific ethnic affiliations in a particular county, the seasonal patterns that determine when communities are accessible, and the informal authority structures that determine whether a message will be trusted or rejected. Local organizations know these things not because they are inherently more virtuous than their international counterparts but because they live in the contexts in which they work. CARE International's women's savings groups in Wau succeeded partly because CARE invested in understanding local financial norms before designing the program. The local knowledge was not supplementary. It was the design. The second benefit is accountability. When communities have a genuine relationship with the organizations delivering services to them, when they can attend meetings, raise grievances, and expect responses, aid is more likely to reach its intended beneficiaries and less likely to be captured by gatekeepers. Norwegian Church Aid's psychosocial support work in Malakal, conducted through local faith institutions that communities already trusted, achieved higher participation rates than comparable programs delivered through unfamiliar channels. Trust is not a soft variable. In conflict-affected settings, it determines whether people engage with a program at all.

The third benefit is institutional continuity. International organizations leave. Local organizations stay. The ECD centres established by Help a Child in Pibor and Tonj North continued operating after the initial project funding ended because local caregivers had been trained and local communities had taken ownership of the infrastructure. This is what the localization literature means by sustainability, not a rhetorical commitment to lasting impact, but a concrete transfer of skills, assets, and institutional memory to actors who will still be present in five years. When local actors are genuinely given authority rather than merely included nominally, the outcomes are more contextually appropriate, more efficiently delivered, and significantly more durable over time.

## Challenges and Lessons Learned in Localization

While localization offers significant advantages, it also presents real obstacles. Limited resources, gaps in technical expertise among local actors, and resistance from external practitioners accustomed to top-down approaches are among the most commonly cited barriers. These challenges are interconnected: overcoming them requires not only financial investment but a genuine shift in institutional culture. The scarcity of resources is the most immediate constraint. Local organizations often operate on shoestring budgets, making long-term planning nearly impossible.

Financial limitation translates directly into gaps in infrastructure, technology, and access to training. Without adequate resources, even the

most promising local initiatives risk stagnating before they can demonstrate impact. The EU and ECHO have supported local organizations in South Sudan by funding projects to enhance technical skills and infrastructure. In Aweil, EU-backed agricultural cooperatives have helped local farmers adopt more productive techniques, an example of technical capacity transfer that leaves lasting capabilities rather than project-specific outputs. Resistance from external actors accustomed to centralized decision-making is equally structural. Traditional aid systems often prioritize institutional control in ways that marginalize community voices, a problem that is not solved by goodwill declarations but only by changing the funding and accountability structures that make centralized control the path of least resistance. ECHO's disaster preparedness programs have demonstrated that giving communities genuine ownership of planning and response tools produces more effective outcomes than managing those tools from outside. The lessons from South Sudan are consistent: localization works best when it is adaptive rather than templated, collaborative rather than subcontracted, and committed to the long-term rather than bounded by project cycles. Building local capacity and institutional trust takes time, but the evidence from Pibor, Wau, and Tonj North demonstrates that the investment pays dividends that externally managed programming consistently fails to produce.

## The Complexity of Localization and Examples in Practice

The implementation of localization in South Sudan faces significant challenges despite its recognized benefits. Internal and external factors, such as power imbalances, resource disparities, and governance fragility, often impede effective collaboration between local organizations and international actors. As [7] has argued, without structural reforms, localization risks becoming mere rhetoric rather than a genuinely transformative approach. Traditional governance structures, such as community chiefs, play vital roles in mediating disputes; external programs that ignore these customs risk undermining the very local authority on which lasting peace depends.

The Grand Bargain commits to 25 percent local funding. Actual delivery remains well below that target. Programs supported by the EU, DRA, ECW, and ECHO have taken steps in the right direction, with community-led flood response and education initiatives providing concrete examples of what local leadership can achieve. Yet, persistent barriers limited access to direct funding, bureaucratic requirements calibrated for large organizations, and under-representation in global policy forums continue to obstruct progress. The South Sudan Council of Churches has used traditional conflict-resolution community dialogues, led by elders, to build peace and restore trust in contexts where formal mediation had failed. Women-led groups in Bor and Rumbek have taken the lead on environmental practices that address food security at the local level. ECW has prioritized community input in rebuilding schools and training teachers, ensuring that curricula reflect the specific realities of displaced children. These are not isolated examples. They are evidence of a consistent pattern: when local actors are given real authority and real resources, they produce outcomes that externally designed programming cannot match. The gap between what the Grand Bargain promises and what is actually delivered in South Sudan is primarily a political problem, not a technical one. Addressing it requires donors to make deliberate choices about where authority sits, not to commission reports about it.

## Challenges of Localization in South Sudan

The obstacles confronting localization in South Sudan are structural. They will not be resolved by goodwill statements or minor

adjustments to existing funding models. Donor funding flows predominantly through large international NGOs and UN agencies. The compliance requirements attached to that funding include audit trails, procurement standards, reporting formats, and financial management systems, which are designed for organizations with significant administrative infrastructure. Most South Sudanese NGOs lack that infrastructure. They are not disorganised; they are under-resourced relative to the compliance burden placed on them. The result is predictable: donors trust international organizations they know, local organizations remain in a subcontracting position, and the rhetoric of localization proceeds independently of the funding reality. As [3] has documented, project-based funding cycles also make long-term institutional development nearly impossible. An organisation cannot build financial management capacity if its funding horizon is twelve months. Political instability compounds these structural barriers. Since the civil war resumed in 2013, many South Sudanese professionals have left the country. The skilled workforce available to staff local NGOs has contracted sharply. Those who remain operate in an environment where insecurity periodically closes field sites, where government officials sometimes extract resources from aid programs, and where ethnic affiliation can compromise an organization's access to specific communities. These are not conditions under which local capacity building proceeds smoothly.

Ref. [3] makes the argument directly: localization risks becoming rhetorical unless the structural conditions that marginalize local actors are changed rather than merely criticized. The same dynamics that produce aid dependency at the community level, with international actors controlling resources, setting agendas, and defining success criteria, reproduce themselves at the organizational level, with local NGOs dependent on international NGOs. Breaking this chain requires deliberate choices by donors: flexible funding, longer grant periods, reduced compliance overhead, and willingness to accept that local organizations will sometimes make decisions that international partners would not have made. Cultural and linguistic diversity adds another layer of complexity. The country has over 60 distinct ethnic groups. Peacebuilding approaches that work in Dinka-speaking communities in Jonglei may be inappropriate among Nuer communities in Upper Nile. Local organizations, in principle, possess the knowledge to navigate these distinctions but only if they are given the authority to apply it.

## Political Instability and its Impact on Local Capacity Building

Political instability in South Sudan has severely undermined local capacity-building efforts, obstructing development and reinforcing dependence on external assistance. The ongoing conflict disrupts governance, erodes institutions, and eliminates the stable platforms that local participation requires. IGAD has attempted to mediate and support peace processes, but those efforts are frequently hampered by unrest and deep-seated divisions within the country. Since the civil war resumed in 2013, humanitarian aid has focused primarily on immediate relief rather than long-term skill development, a pattern that leaves communities chronically ill-equipped to achieve lasting progress. The instability has curtailed local actors' contributions to peacebuilding and development initiatives, shrinking the space for community-driven projects. Communities most affected by violence lose access to the resources and decision-making platforms necessary to rebuild. The absence of local input exacerbates marginalization and undermines the legitimacy of externally driven solutions. Political instability has also hindered cross-border collaboration and technology exchange, both of which are important for local innovation and economic development. Regional economic

studies confirm that unstable governance restricts effective partnerships, leaving South Sudan isolated from broader developmental networks [1].

South Sudan's brain drain is not metaphorical. The professionals who might staff local NGOs have left, and the pipeline to replace them has not been built. Without investment in education and vocational training, communities lack the expertise to lead their own development, and local organizations remain dependent on international actors to fill technical and managerial roles, perpetuating the cycle. The concentration of resources within political elites has produced inequitable resource distribution that directly disadvantages grassroots organizations. Local NGOs struggle to compete with international actors for donor funding, which is often allocated according to criteria that favor established international organizations, thereby widening the institutional gap rather than closing it [7].

Donors, including the EU, DRA, ECW, and ECHO, have recognized the importance of political stability to progress in localization. ECW's investments in education have given local youth opportunities to develop leadership skills. DRA's funding mechanisms have sought to build local organisational capacity by prioritising collaboration over subcontracting. However, these efforts remain constrained by the broader political environment. Governance accountability gaps undermine donor confidence and limit the scale at which successful localization models can be replicated [3]. Without enduring peace, localization will continue to be thwarted by the realities of conflict and instability. Addressing this requires a dual focus: investing in political stability alongside investing in local capacity building. Neither alone is sufficient.

## Best Practices and Strategies for Effective Localization

What distinguishes localization that works from localization that merely looks good on paper is not ideology. It is designed. Across the South Sudan cases reviewed in this study, the programs that produced durable results shared a small number of concrete features: communities were involved in identifying priorities before program design began; local knowledge shaped implementation rather than decorating it; and accountability ran toward communities, not only toward donors. These are not abstract principles. They are observable design choices, and their presence or absence is often what separates programs that outlast their funding from those that collapse when the grant ends. IGAD mediators have at times struggled to craft strategies that genuinely reflect local dynamics precisely because mediation frameworks were designed externally and applied uniformly.

Ref. [6] draws a useful parallel to multinational corporations managing the tension between standardized global operations and locally responsive practices. The analogy holds for humanitarian organizations: programs calibrated to a specific county in Upper Nile will not perform the same way in Central Equatoria, and organizations that acknowledge this consistently produce better outcomes. CARE's community-led workshops in Wau, which identified local agricultural priorities before any program was designed, are a case in point. FCA's work integrating peace education into school curricula in Aweil succeeded because FCA first sat down with teachers, parents, and community leaders. Help a Child's psychosocial programs in Pibor trained local people to deliver care in their own language to their own communities. The cultural accuracy was built in from the start, not retrofitted. In each case, the approach required more time at the design stage and more willingness to adapt to what communities said they needed. The

payoff was programs that communities accepted and, in some cases, continued running independently after external funding ceased.

Monitoring and evaluation mechanisms that include genuine community feedback are not bureaucratic formalities. They are the mechanism by which programs earn, or lose, community trust. War Child's programs in Wau incorporated feedback loops that directly informed mid-implementation adjustments. Dorcas' microfinance program in Pibor outlasted its project cycle because the people running it had genuine ownership of both the model and the decision-making. That ownership was not incidental. It was the intended outcome of the program's design. The IRC has incorporated local knowledge into health interventions in Pibor by training community health workers rather than rotating external staff through. The evidence is consistent and replicable: when local actors are given real authority and real accountability, they produce better outcomes than internationally managed alternatives operating in the same contexts.

## Research Methodology

This study examined the systemic factors shaping localization in South Sudan through a qualitative design combining case study analysis, semi-structured interviews, and document review. A qualitative approach was selected because the central questions of how power is distributed between international and local actors, how cultural context shapes program outcomes, and why localization succeeds in some settings and fails in others are not well served by quantitative measurement. They require interpretive analysis of how people understand and act within complex social and institutional arrangements [2]. Case studies were drawn from Wau, Bor, Pibor, and Malakal to capture variation in context, organizational type, and program model. By examining how localization has played out differently across these settings, the study identified patterns that hold across contexts, as well as dynamics specific to particular communities or conflict histories.

This cross-case comparative approach is consistent with [5]'s recommendations for case study research aimed at generating theoretical insight rather than simply describing individual instances. Semi-structured interviews were conducted with representatives from local NGOs, international agencies, government officials at the county and state levels, community leaders, and donors. The semi-structured format allowed interviewees to raise issues beyond the predetermined questions and the most analytically significant material often emerged in precisely this way. Interview data were triangulated with policy documents, project evaluations, donor reports, and academic literature, which provided a broader institutional and political context for interpreting interview participants' on-the-ground accounts. Thematic analysis was used to organize and interpret the qualitative data, with codes developed inductively from the data rather than imposed from a predetermined framework. Ethical standards were observed throughout: participation was voluntary, identities were protected, and data were handled in accordance with the principles outlined by [2].

### Successful Case Studies and Lessons Learned from Local Organizations in South Sudan

Case studies from South Sudan demonstrate the significant potential for advancing localization in humanitarian work while challenging conventional aid models. Local organizations, deeply embedded within their communities, have consistently demonstrated the capacity to address immediate needs while building longer-term recovery precisely because they use culturally appropriate, context-specific methods that external actors cannot readily replicate.

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The South Sudanese Development Organization offers the clearest example of what happens when customary authority is taken seriously rather than bypassed. By integrating traditional conflict resolution into its programming using community elders and customary mediation techniques, SSDO has resolved local disputes, reduced violence, and strengthened social cohesion in areas where internationally designed peace processes made little headway. This approach has not only generated tangible outcomes but also built trust among communities that have historically been skeptical of external interventions. The community initiative to establish Early Childhood Development centres in Pibor and Tonj North provides an equally instructive case.

Help a Child provided the initial support, trained caregivers in child-centered learning approaches, and equipped the centers. But what made the initiative durable was that communities took ownership: in Pibor, community members repurposed an abandoned structure, with local women volunteering as caregivers and teachers. The program prepared children for formal schooling while providing stability amid ongoing conflict. The ECD center also became a hub for community engagement, hosting parenting workshops, nutrition sessions, and child health activities that extended the program's reach well beyond the classroom. In Tonj North, the ECD center was built using locally sourced materials, with ongoing mentorship from Help a Child, ensuring that teaching methods remained effective over time. When project funding eventually ended, the centres continued operating. That outcome is not routine in South Sudan. It happened because local ownership was built into the program's design from the start, rather than added as an afterthought once international implementation was complete. The lesson is simple: localization works when external support amplifies local efforts without displacing local leadership.

## The Role of Donors in Supporting Localization Efforts

Donors, including the European Union (EU), the Dutch Relief Alliance (DRA), Education Cannot Wait (ECW), and ECHO, have played important roles in advancing localization in South Sudan. Their contributions have varied in approach and depth, but each has demonstrated that direct investment in local partnerships can produce more contextually grounded outcomes than funding channeled primarily through large international intermediaries.

1. **EU:** EU-funded projects in Wau and Aweil have supported agricultural cooperatives, raising productivity and improving food security in ways that outlast individual project cycles. The EU has also invested in strengthening local governance, giving communities greater control over their own development priorities.
2. **DRA:** In Pibor, DRA funding enabled local organizations to provide emergency relief and build infrastructure for sustainable water access, combining immediate need and long-term utility in a single investment rather than treating them as sequential phases.
3. **ECW:** ECW has collaborated with South Sudanese organizations to rebuild schools and train teachers in conflict-affected areas. By engaging local communities throughout, not just at the implementation stage, these initiatives have produced education programs contextually relevant enough to continue after external funding ends.
4. **ECHO:** ECHO's support in Aweil has helped community-based organizations develop early warning systems that reduce vulnerability to floods. This is capacity being built, not bypassed, and it is the model that creates durable local competence rather than durable dependence.

## Bridging Humanitarian Aid and Development

The humanitarian-development divide is a familiar problem in fragile states, and South Sudan illustrates it acutely. Emergency relief responses are funded on short cycles, staffed by rotating personnel, and evaluated on whether acute needs were met, not on whether communities became less vulnerable over time. Development programming requires longer time horizons, local institutional investment, and tolerance for slow, non-linear progress. The two rarely coexist comfortably within the same funding architecture.

But they can coexist. The evidence from South Sudan is clear about what makes it possible. War Child's psychosocial and vocational programs in Juba worked because they did not treat trauma support and economic skills development as separate activities; they were designed together, delivered together, and evaluated together. Dorcas's microfinance schemes in Wau worked because they built on existing community savings structures rather than introducing parallel systems that communities would need to learn from scratch and that would disappear when the project did. WFP's food-for-assets program created physical infrastructure while meeting immediate food needs, with communities engaged as builders rather than passive recipients, a design that converts short-term relief into long-term assets.

Help a Child's early childhood development work in Pibor and Tonj North did not begin as a crisis response, and later added development elements. It was designed from the outset as a long-term community institution, built with local materials, staffed by locally trained people, and sustained by community ownership. When project funding ended, the centres continued. [5] argue that moving beyond the humanitarian-development divide requires treating the two not as sequential phases but as simultaneous design goals. In South Sudan, this means emergency food distributions organized through local associations where they exist; health clinics built during crisis responses staffed by locally trained health workers; and the institutional relationships formed in emergency contexts invested in as development assets. This reorientation does not require new funding. It requires different priorities for how existing funding is allocated and for whom to trust to manage it.

## Key Lessons from Local Organizations

Several consistent lessons emerge from the record of local organizations in South Sudan:

1. Community ownership makes the difference between programs that last and programs that do not. CARE's community-led savings groups in Wau have shown consistent results because participants helped design the model and have a direct stake in sustaining it, not because CARE told them to participate.
2. Cultural relevance is not a soft criterion. Incorporating traditional conflict resolution mechanisms and indigenous knowledge builds the kind of trust that determines whether communities engage with a program at all. Aid delivery that bypasses these structures may meet targets on paper while failing to reach people in practice.
3. Capacity investment must be sustained long enough to actually transfer. FCA's leadership training for women in Pibor produced durable outcomes because the investment continued past a single project cycle not because a capacity-building component was appended as a compliance requirement to satisfy a donor report.
4. Collaboration that respects local context outperforms subcontracting. The IRC's community health worker model in Pibor produces better health outcomes than equivalent programs staffed by rotating external personnel, because the workers delivering care share the language, history, and social context of the people they serve.

## Sustainability and Resilience

Programs that prioritize local leadership and capacity are more likely to outlast external funding, not because local actors are inherently more committed, but because they have nowhere else to go. ECW's teacher training has kept schools in remote areas running through periods of insecurity when international staff withdrew. DRA's support for community-based disaster risk reduction has given local actors the tools and institutional legitimacy to manage crises without waiting for external authorization. The record from South Sudan makes a clear, practical case: anchor programs in community ownership, ensure cultural relevance through genuine co-design, invest in local organizational capacity as a program goal rather than as an overhead cost, and build collaboration that respects, rather than circumvents, local authority. Donors the EU, DRA, ECW, and ECHO have demonstrated through their South Sudan portfolios that supporting local actors is the most effective way to achieve durable outcomes in a context where international capacity will always be temporary. The only resource that will remain after the next funding cycle ends is community capacity. That is where investment needs to go, not as a supplementary activity, and not at the scale of a percentage point of a global budget, but as the deliberate, multi-year, institutionally serious commitment that the South Sudan evidence shows it needs to be.

## Summary of Key Points and the Future of Localization Practices in South Sudan

The evidence reviewed in this paper consistently points in one direction: localization in South Sudan yields better, more durable outcomes when local actors have real authority, when programs are built around community knowledge, and when funding relationships are structured for long-term institutional development.

Where these conditions have been present in Pibor, in Wau, in Tonj North, the record is encouraging. The women's groups organizing savings in Wau, the elders mediating disputes in Pibor, the caregivers running ECD centers in Tonj North, these are not success stories manufactured by international organizations. They are evidence of what local actors can do when the structures around them support rather than obstruct local leadership. South Sudan's agricultural landscape is diverse and context-specific in ways that generic food security programming routinely misreads. Development priorities anchored in local knowledge, rather than imported from external frameworks, are more likely to reflect what communities actually need and to produce outcomes that last. The gap between international aid strategies and what communities report as their actual priorities is not an accident. It reflects a system in which communities have limited formal power over the design of the programs that serve them. Closing that gap requires institutional changes in who designs programs, who holds decision-making authority, and who is accountable for results. These changes are achievable. What they require is a political decision to prioritize them over the institutional convenience of the status quo.

## Bridging Gaps between International Aid and Local Realities

International organizations too often operate within frameworks calibrated for standardized reporting rather than adaptive programming. The compliance structures attached to international funding effectively penalize the kind of responsive, community-led adaptation that localization requires. An organisation cannot simultaneously meet tight reporting deadlines, maintain a paper trail calibrated to international audit standards, and genuinely adapt its programming to what communities tell it in real time. Something gives, and it is usually the responsiveness. Genuine partnerships require local organizations to be in the room when decisions about program design, budget allocation, and evaluation criteria are made.

South Sudan's experience demonstrates that this kind of shared decision-making produces programs that are more trusted by communities, more accurately targeted, and more likely to continue after project funding ends. The challenge is building funding and governance structures that make it the default rather than the exception.

### Investing in Local Capacity

Capacity investment is not a program component. It is a multi-year commitment that requires funders to accept that the returns will arrive slowly. The organizations in South Sudan that have made real differences, SSDO in Pibor, Help a Child in Tonj North, and Dorcas in Wau, did so because someone made the decision to invest in local institutional capacity and then stayed long enough to see it mature. Short grant cycles, heavy compliance burdens, and a preference for measurable short-term outputs are the structural enemies of that kind of investment. Where capacity has been systematically built through leadership training, financial management skills, governance development, and long-term mentoring, local organizations have repeatedly demonstrated an ability to address the structural roots of both poverty and conflict that internationally managed programming cannot match.

### Inclusive Governance

Decisions about aid programs should involve the people those programs affect. That principle is straightforward but consistently violated in practice. In South Sudan, women, youth, and ethnic minorities are frequently excluded from the formal decision-making processes that shape humanitarian responses to their own communities. The participatory governance literature is unambiguous on what this costs: programs designed without the input of affected populations are less accurate, less trusted, and less durable. South Sudan's deep ethnic and political divisions make this even more consequential; governance processes that exclude significant groups do not just produce worse programs; they actively reinforce the divisions that localization is supposed to help address.

### Building for the Long Term

What the future of localization in South Sudan requires, above all else, is that the institutions involved accept that sustainable change does not happen on project timelines. Flexible funding structures, honest accountability upward and downward, the willingness to adapt when communities report that something is not working, and a genuine transfer of authority to local actors: these are the preconditions. They are achievable. What they require is a political decision to prioritize them over the institutional convenience of the status quo.

## Conclusions

The localization agenda in South Sudan is real, but it is also unfinished and in some respects contradictory. Donors and international agencies have committed, in principle, to shifting power and resources to local actors. In practice, the compliance requirements attached to international funding, the short-term nature of project cycles, and the institutional inertia of large organizations continue to reproduce the very dependency they claim to be dismantling. The gap between localization's promise and its delivery is not a technical problem. It is a political one.

Closing it requires that international actors' donors, UN agencies, and large INGOs make deliberate choices to reduce institutional barriers for local organizations, extend funding time horizons, and accept a reallocation of authority that will, in the short term, produce uncertainty. The cases reviewed in this paper, Pibor, Wau, Tonj North, Bor, Malakal, show that effective localization is achievable. The SSDO's use of customary mediation reduced inter-group violence in areas where

international peacebuilding had made little headway. Help a Child's ECD centres outlasted their project funding. CARE's savings groups in Wau strengthened financial resilience among women excluded from formal economic institutions. These are not isolated anecdotes. They reflect a consistent pattern: when local actors are given genuine authority and adequate resources, they produce outcomes that externally driven programs do not.

The Overseas Development Institute has documented that local actors typically have deeper community access, greater trust, and stronger contextual knowledge than international agencies. Dorothea Hilhorst has argued that localization must involve a genuine structural shift in power, not nominal inclusion, if it is to produce meaningful change. The evidence from South Sudan supports both conclusions. The question is not whether to localize. It is whether the institutions that control humanitarian resources are prepared to make the structural changes that localization actually requires. South Sudan remains one of the world's most challenging humanitarian contexts. The localization debate there is not academic. It shapes whether communities receive aid relevant to their actual situation, whether local organizations develop into durable institutions, and whether the country's long-term recovery is built on local foundations or on internationally managed dependency. The answer depends less on declarations than on concrete shifts in funding, authority, and institutional trust.

## Recommendations

Based on the analysis above, the following recommendations are directed to the distinct actors who bear the most responsibility for the state of localization in South Sudan.

### For International Donors

Restructure funding mechanisms to reduce the compliance gap. The administrative requirements currently attached to direct local funding are calibrated for organizations with substantial administrative capacity. Donors should develop a tiered compliance framework that adjusts reporting requirements to organizational size and risk level, making direct local funding genuinely accessible rather than nominally available. Extend grant periods: a twelve-month funding cycle is incompatible with institutional capacity development. Three- to five-year core funding agreements, where feasible, would represent a significant structural shift. Track actual, not nominal, localization by requiring transparent reporting on real decision-making authority, not just financial flows.

### For International NGOs and UN Agencies

Distinguish between subcontracting and partnership. Engaging a local organization to implement an externally designed program is not localization. Genuine partnership requires including local organizations in needs assessment, program design, and evaluation, not only in service delivery. Invest in local organizational development as a program goal rather than an afterthought. Reduce staff rotation: frequent rotation of international staff destroys institutional knowledge and community relationships. Where possible, agencies should extend assignment lengths and prioritize retention of local national staff.

### For Local NGOs and Community-based Organizations

Build coalitions. Individual local organizations competing separately for limited direct funding are at a structural disadvantage relative to large international NGOs. Coalitions and consortia, such as the South Sudan Joint Response model, increase negotiating leverage and allow smaller organizations to share administrative costs. Document outcomes systematically: the capacity to produce credible evidence of program impact is one of the key barriers preventing local organizations from securing direct donor funding. Engage

traditional and community institutions deliberately rather than working around them.

**For the Government of South Sudan**

Create an enabling environment for local civil society: do not extract resources from aid programs, do not obstruct local NGO registration and operations, and do not selectively target civil society organizations based on ethnic or political affiliations. Political stability and rule of law are not peripheral conditions for localization. They are prerequisites.

**For All Actors Collectively**

Treat localization as a governance question, not a logistical one. The persistent mismatch between localization rhetoric and localization practice in South Sudan reflects a failure of institutional will, not a failure of technical capacity. The path forward requires political decisions by donors to shift resources, by international agencies to share authority, and by all parties to accept that a genuinely locally-led humanitarian system will look different from the internationally managed system currently in place.

## Suggestions for Further Research

1. Evaluating the Impact of Capacity Building Initiatives. To understand which approaches most effectively strengthen the operational sustainability of local NGOs and private enterprises over time.
2. Exploring Community Perspectives on Localization. To gain in-depth insight into how local populations perceive localization efforts in practice, and identify gaps between program intent and lived experience.
3. Assessing the Role of Traditional Conflict Resolution Mechanisms. To determine how indigenous practices can be integrated into formal peacebuilding frameworks in ways that enhance, rather than displace, community authority.
4. Analyzing Partnership Effectiveness Between Local and International Actors. To identify specific institutional arrangements and power-sharing mechanisms that produce equitable and productive collaborations.
5. Investigating Political and Institutional Barriers. To examine how governance instability specifically impedes local organizational development and which institutional reforms have the highest marginal effect on localization outcomes.
6. Longitudinal Studies on Localization Outcomes. To monitor the long-term effects of localization investments over five-to-ten-year periods, providing evidence for policy reform and demonstrating whether short-term outcomes translate into durable institutional change.

## Conflict of Interest

The authors declare that there are no financial or personal relationships with other people or organizations that could inappropriately influence or bias the content of this manuscript.

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## Ethical Approval

This study was conducted in adherence to institutional ethical guidelines. Where applicable, informed consent was obtained from all participants involved in the case studies and from stakeholders whose perspectives are discussed in the journal. The research prioritizes the dignity and agency of

the local populations affected by humanitarian and development agendas.

## Data Availability

The qualitative data and case study analyses supporting the findings of this journal are included within the article. Additional information regarding policy frameworks and stakeholder perspectives can be made available by the corresponding author upon reasonable request.

## Author Contributions

- **Angelo Lubang Paterno Jada:** Conceptualization, methodology, formal analysis, investigation, and writing original draft preparation. The author was responsible for critically examining the practical realities of localization and offering practical recommendations for equitable solutions in South Sudan.
- **Prof. Kadian Wanyonyi Wanyama:** Supervision, conceptualization, writing review and editing, and validation. The co-author provided academic oversight and critical revisions to ensure the study meets the necessary standards for publication and practical application within the South Sudanese context.

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# Community-Based Support Systems and Health System Gaps Affecting Viral Load Follow-up in Pmtct Programs in Cameroon: A Narrative Review

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***Abstract*** *Viral load monitoring remains an essential component of Prevention of Mother-to-Child Transmission (PMTCT) programs because it supports treatment monitoring, promotes viral suppression, and reduces the risk of HIV transmission from mother to child. However, continuity of viral load follow-up among pregnant and breastfeeding women living with HIV continues to face several challenges in Cameroon. This narrative review examined community-based support systems and health system gaps affecting viral load follow-up within PMTCT programs in Cameroon. A narrative review approach was used to synthesize evidence from quantitative studies, qualitative studies, mixed-method research, technical reports, and policy documents published between 2010 and 2026. Electronic databases including PubMed, Google Scholar, Scopus, African Journals Online, and Web of Science were searched alongside reports from the World Health Organization, UNAIDS, and the Cameroon National AIDS Control Committee. The review identified delayed laboratory result turnaround time, shortage of healthcare personnel, weak patient tracking systems, stigma, transportation difficulties, poor male partner involvement, and insecurity in conflict-affected regions as barriers affecting continuity of viral load monitoring. Community-based interventions such as mentor mother programs, peer support groups, community health worker follow-up, adherence counseling, and mobile phone reminders were found to improve retention in care, adherence to antiretroviral therapy, and continuity of PMTCT follow-up services. The review concludes that strengthening healthcare systems alongside expansion of community-based support interventions may improve viral load follow-up and PMTCT outcomes in Cameroon. Further implementation research is needed to evaluate context-specific approaches for improving continuity of HIV care among pregnant and breastfeeding women.*

***Keywords*** *Cameroon, Community-based Support Systems, HIV, Maternal Health, PMTCT, Viral Load Follow-up.*

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## Introduction

Human Immunodeficiency Virus (HIV) infection continues to be a major public health challenge globally, particularly in sub-Saharan Africa where women and children remain disproportionately affected. Despite significant progress in the scale-up of antiretroviral therapy (ART) and Prevention of Mother-to-Child Transmission (PMTCT) services, vertical transmission of HIV remains a concern in many low- and middle-income countries, including Cameroon. Viral load monitoring has become a central component of PMTCT programs because it helps evaluate treatment effectiveness, monitor adherence to ART, and reduce the risk of HIV transmission from mother to child during pregnancy, delivery, and breastfeeding [1].

The World Health Organization recommends routine viral load testing for pregnant and breastfeeding women living with HIV to ensure early identification of treatment failure and sustained viral suppression throughout the PMTCT period [2]. Women who maintain suppressed viral load while receiving ART have significantly lower chances of transmitting HIV to their infants. Viral load monitoring also provides an important opportunity for healthcare providers to identify adherence challenges and provide timely interventions to improve maternal and child health outcomes.

In Cameroon, substantial efforts have been made to strengthen PMTCT services through the expansion of HIV testing, integration of ART services into maternal healthcare, decentralization of treatment centers, and implementation of national HIV control strategies. Support from international partners such as the World Health Organization, UNAIDS, the Global Fund, and PEPFAR has contributed to increased access to HIV care and treatment services across the country [3]. Despite these efforts, continuity of care and viral load follow-up among pregnant and breastfeeding women remain suboptimal in several regions of Cameroon.

A number of health system gaps continue to affect the effectiveness of viral load monitoring within PMTCT programs in Cameroon. Delayed laboratory processing, prolonged turnaround time for viral load results, shortages of trained healthcare personnel, weak patient tracking systems, stock-outs of laboratory supplies, and inadequate counseling services have been reported in different healthcare settings [4]. In conflict-affected regions such as the North West and South West Regions, insecurity, population displacement, and temporary disruption of health services have further weakened continuity of HIV care among pregnant and breastfeeding women [5].

Community and social factors also play a major role in influencing adherence to PMTCT services and viral load follow-up. HIV-related stigma, fear of disclosure, poor male partner involvement, poverty, transportation difficulties, and cultural beliefs continue to affect women's willingness and ability to remain engaged in HIV care throughout pregnancy and breastfeeding [6]. Women who lack social or family support are more likely to miss clinic appointments, interrupt treatment, or become lost to follow-up.

To address these challenges, community-based support systems have increasingly been integrated into PMTCT interventions in Cameroon. Programs involving mentor mothers, peer educators, community health workers, support groups, adherence counseling, and home visits have shown promising results in improving retention in care, adherence to ART, and linkage to viral load monitoring services [7]. These interventions help bridge the gap between healthcare facilities and communities by providing psychosocial support, treatment education, follow-up, and encouragement for continued participation in PMTCT services.

Although several studies and reports have explored PMTCT implementation and HIV

care in Cameroon, evidence relating specifically to community-based support systems and health system gaps affecting viral load follow-up remains fragmented. There is limited narrative synthesis bringing together existing findings on how these factors influence continuity of care and viral suppression among pregnant and breastfeeding women living with HIV in Cameroon.

This narrative review therefore examines existing evidence on community-based support systems and health system gaps affecting viral load follow-up in PMTCT programs in Cameroon. The review aims to identify major barriers, facilitators, and opportunities for strengthening continuity of care and improving viral suppression outcomes among pregnant and breastfeeding women living with HIV.

## Materials and Methods

This study was conducted as a narrative review to synthesize available evidence on community-based support systems and health system gaps affecting viral load follow-up among pregnant and breastfeeding women living with HIV in Cameroon. A narrative review approach was considered appropriate because of the limited number of Cameroon-specific studies directly addressing viral load follow-up within PMTCT programs and the diversity of available evidence, including quantitative studies, qualitative studies, mixed-method research, technical reports, and policy documents.

A comprehensive literature search was conducted between January and March 2026 using electronic databases including PubMed, Google Scholar, Scopus, African Journals Online (AJOL), and Web of Science. Additional information was obtained from reports published by the World Health Organization (WHO), UNAIDS, the Cameroon Ministry of Public Health, the National AIDS Control Committee (NACC), the Global Fund, and PEPFAR-supported programs. Search terms included “viral load follow-up,” “viral load monitoring,” “PMTCT,” “pregnant women living with HIV,” “breastfeeding women,” “community-based support,” “mentor mothers,” “health system barriers,” “retention in care,” and “Cameroon.” Boolean operators such as AND and OR were used to refine the search process.

Studies were included if they focused on Cameroon or contained findings relevant to PMTCT, viral load monitoring, retention in HIV care, adherence challenges, health system barriers, or community-based support interventions among pregnant and breastfeeding women living with HIV. Quantitative studies, qualitative studies, mixed-method studies, technical reports, and policy documents published between 2010 and 2026 in English or French were eligible for inclusion.

Relevant information from selected studies was extracted and synthesized narratively under major thematic areas including health system gaps, community and social barriers, community-based support systems, and conflict-related challenges affecting viral load follow-up within PMTCT programs in Cameroon.

## Results

### Characteristics of Reviewed Studies

A total of 15 relevant articles and reports published between 2017 and 2023 were included in this narrative review. The reviewed literature consisted of quantitative studies, qualitative studies, mixed-method research, national reports, and technical documents focusing on PMTCT services, viral load monitoring, retention in care, community-based support systems, and health system barriers affecting pregnant and breastfeeding women living with HIV in Cameroon [8]. Most of the studies were conducted in hospital settings, HIV treatment centers, PMTCT clinics, and conflict-affected communities within the country. The findings from the reviewed studies consistently highlighted challenges related to continuity of care, delayed viral load

monitoring, stigma, transportation difficulties, weak patient follow-up systems, and shortage of healthcare personnel (Table 1).

**Table 1.** Characteristics of Studies Included in the Narrative Review [8–15]

| Authors | Year | Study Design | Main Focus | Key Findings | Relevance to the Review |
|---|---|---|---|---|---|
| Tchendjou et al. | 2021 | Quantitative | Retention in PMTCT care | Poor retention reduced continuity of viral load monitoring and ART adherence. | Demonstrates linkage between retention and viral load follow-up. |
| Ndzi et al. | 2019 | Qualitative | HIV stigma and adherence | Fear of disclosure and stigma affected clinic attendance and adherence. | Explains social barriers affecting PMTCT continuity. |
| Fokam et al. | 2022 | Quantitative | Viral load turnaround time | Delayed viral load results affected continuity of HIV monitoring. | Highlights laboratory-related health system gaps. |
| Penda et al. | 2020 | Mixed-method | Access barriers to PMTCT | Transportation and financial difficulties affected clinic attendance. | Identifies structural barriers to follow-up. |
| Nguefack-Tsague et al. | 2018 | Quantitative | Social support and adherence | Family support improved adherence among women receiving ART. | Supports importance of community and family support systems. |
| Fonsah et al. | 2017 | Quantitative | Retention and viral suppression | Retention in care improved viral suppression outcomes. | Connects continuity of care to viral load suppression. |
| Ndziessi et al. | 2022 | Mixed-method | Conflict and continuity of HIV care | Insecurity disrupted PMTCT service utilization. | Shows impact of conflict on viral load follow-up. |
| Sama et al. | 2021 | Qualitative | Cultural beliefs and HIV care | Cultural misconceptions contributed to treatment interruption. | Explains sociocultural barriers affecting adherence. |
| Tita et al. | 2020 | Quantitative | Health service barriers | Long waiting times discouraged follow-up attendance. | Identifies healthcare delivery gaps. |
| CAMPHIA Report | 2020 | National Survey | HIV care cascade | Gaps in viral suppression and continuity of HIV | Provides national PMTCT and viral suppression context. |

| | | | | | |
|---|---|---|---|---|---|
| | | | | care were identified nationally. | |
| NACC Report | 2023 | National Report | HIV program performance | PMTCT follow-up challenges remained significant. | Provides current Cameroon HIV program context. |
| WHO Report | 2021 | Technical Report | HIV monitoring guidelines | Viral load monitoring remains essential for PMTCT success. | Supports global recommendations on PMTCT monitoring. |
| UNAIDS Report | 2023 | Global/National Report | HIV continuity of care | Community-centered interventions improved retention in care. | Supports community-based approaches. |
| World Bank Report | 2022 | Technical Report | Conflict and healthcare access | Insecurity disrupted maternal and HIV services. | Demonstrates structural challenges in conflict settings. |
| Cataldo et al. | 2017 | Qualitative Review | Mentor mother programs | Mentor mothers improved adherence and psychosocial support. | Supports effectiveness of community support interventions. |

## Health System Gaps Affecting Viral Load Follow-Up

The literature reviewed shows that several weaknesses within the healthcare system continue to affect viral load follow-up among pregnant and breastfeeding women living with HIV in Cameroon. One of the challenges most frequently reported was the delay in processing viral load samples and returning results to health facilities. In many settings, laboratories struggled with limited equipment, shortage of reagents, and poor coordination between peripheral clinics and reference laboratories. These delays often slowed clinical decision-making and affected timely patient management.

Many studies also pointed to inadequate human resources as a major concern within PMTCT services. In several facilities, healthcare workers managed large numbers of patients with limited staff support. This situation reduced the amount of time available for counseling, patient education, adherence monitoring, and follow-up of missed appointments. Long waiting hours at treatment centers further discouraged some women from attending regular clinic visits for ART refill and viral load monitoring.

Weak record-keeping and patient tracking systems were also identified as barriers affecting continuity of care. In some facilities, follow-up systems for women who missed appointments were either weak or absent. Poor coordination between maternal health clinics, HIV treatment units, and laboratory services sometimes resulted in interrupted follow-up and delayed care.

## Community and Social Barriers Affecting PMTCT Follow-up

Beyond the health system, several social and community-related challenges were found to influence adherence and continuity of PMTCT services. HIV-related stigma remained a common problem across many studies reviewed. Fear of discrimination, rejection, or

negative reactions from relatives and community members caused some women to hide their HIV status, avoid clinic attendance, or interrupt treatment during pregnancy and breastfeeding.

Limited male partner involvement was another issue repeatedly highlighted in the literature. Women who lacked emotional, social, or financial support from their partners were more likely to miss appointments and experience difficulties maintaining regular follow-up. Financial hardship also affected continuity of care, especially among women living in rural communities where transportation costs and long distances to health facilities remained major obstacles.

Some studies additionally reported that cultural beliefs and misconceptions surrounding HIV treatment contributed to poor adherence among certain groups of women. In a few communities, traditional treatment practices and misinformation regarding ART discouraged some women from remaining fully engaged in PMTCT services.

## Community-based Support Systems and Facilitators

Despite these difficulties, the review showed that community-based support systems continue to play an important role in strengthening PMTCT follow-up and viral load monitoring in Cameroon. Mentor mother programs were consistently identified as one of the most beneficial community interventions. Women supported by mentor mothers often demonstrated better adherence to treatment, improved clinic attendance, and greater confidence in continuing care during pregnancy and breastfeeding.

Community health workers and peer educators also contributed positively through home visits, counseling, appointment reminders, and tracing of women who missed scheduled clinic visits. These interventions helped strengthen the connection between health facilities and communities while improving continuity of HIV care.

Support groups for women living with HIV were similarly reported to provide emotional support, encouragement, and opportunities for experience sharing. In some settings, mobile phone reminders and follow-up calls also helped improve attendance at clinic appointments and viral load monitoring visits.

## Conflict-Related Challenges Affecting Viral Load Follow-up

The review further revealed that insecurity and armed conflict continue to affect PMTCT service delivery in some parts of Cameroon, particularly within the North West and South West Regions. Displacement of populations, temporary closure of health facilities, road insecurity, and movement restrictions disrupted access to HIV care among pregnant and breastfeeding women.

Women living in conflict-affected communities often faced interruptions in ART refill appointments and missed viral load monitoring visits because traveling to health facilities became difficult or unsafe. Some women relocated to other communities without proper transfer of medical records, increasing the likelihood of treatment interruption and loss to follow-up.

The insecurity also affected healthcare workers and community-based interventions. Outreach activities, home visits, and community follow-up services became difficult to maintain in some rural areas. Damaged roads and rising transportation costs further complicated access to healthcare services for many women.

Overall, the reviewed evidence indicates that viral load follow-up within PMTCT programs in Cameroon is influenced by a combination of health system weaknesses, community-level barriers, and conflict-related challenges. At the same time, community-based support interventions appear to offer important opportunities for improving retention in care,

adherence to ART, and continuity of viral load monitoring among pregnant and breastfeeding women living with HIV.

## Discussion

This narrative review examined community-based support systems and health system gaps affecting viral load follow-up among pregnant and breastfeeding women living with HIV in Cameroon. The findings revealed that continuity of viral load monitoring within PMTCT programs is influenced by several interconnected health system, social, economic, and community-related factors [3, 4, 6]. The review also demonstrated that community-based interventions such as mentor mother programs, peer support groups, community health worker follow-up, and adherence counseling continue to play an important role in strengthening retention in care and improving adherence to antiretroviral therapy among pregnant and breastfeeding women living with HIV [7, 16]. These findings are important because continuity of viral load monitoring remains essential for early detection of treatment failure, maintenance of viral suppression, and reduction of mother-to-child transmission of HIV [2].

One of the major findings from this review was the continued challenge of delayed viral load result turnaround time within PMTCT services in Cameroon. Delayed laboratory processing, shortage of reagents, and weak coordination between peripheral health facilities and reference laboratories were repeatedly identified as barriers affecting continuity of HIV care [4]. Similar findings were reported in Malawi where limited laboratory infrastructure and weak diagnostic systems reduced effective follow-up among pregnant women enrolled in PMTCT services [16]. Comparable observations were also reported in Tanzania where delayed laboratory feedback contributed to interruptions in treatment monitoring and clinical decision-making among women receiving ART [18]. Studies conducted in Uganda also reported that delayed return of viral load results contributed to poor treatment monitoring and reduced retention in PMTCT care among pregnant women living with HIV [21]. According to the World Health Organization, timely viral load monitoring remains one of the most reliable indicators for evaluating treatment effectiveness and reducing the risk of HIV transmission from mother to child [2]. Delays in obtaining viral load results may therefore contribute to late identification of treatment failure and poor maternal and infant health outcomes.

The review further demonstrated that shortage of trained healthcare workers and high patient burden remain important barriers affecting PMTCT follow-up in Cameroon [3]. Several healthcare facilities continue to experience inadequate staffing, particularly within rural and underserved communities. Long waiting times, reduced consultation periods, and limited counseling opportunities discouraged some women from attending regular clinic visits for viral load monitoring and ART refill [11]. Similar findings were reported in Southern African PMTCT settings where shortage of healthcare workers reduced the quality of counseling, adherence support, and patient follow-up services offered to pregnant women receiving HIV care [17]. Comparable studies conducted in Ethiopia and Kenya also found that heavy workload among healthcare providers negatively affected continuity of HIV care and patient monitoring within PMTCT programs [12]. Research conducted in Zambia equally showed that overburdened healthcare systems contributed to missed appointments and interruptions in HIV follow-up among pregnant women receiving ART [22]. These findings suggest that strengthening human resources for health remains essential for improving viral load follow-up and retention in care among pregnant and breastfeeding women living with HIV.

Weak patient tracking and documentation systems also emerged as major barriers affecting continuity of care in Cameroon [9]. Poor coordination between maternal health clinics, HIV treatment services, and laboratory departments contributed to interrupted follow-up and delayed patient management among women enrolled in PMTCT programs. Similar findings were reported in Tanzania where weak follow-up systems increased the risk of treatment interruption during pregnancy and the postpartum period [18]. Studies conducted in South Africa also demonstrated that inadequate patient tracing systems contributed significantly to loss to follow-up among women receiving ART within PMTCT services [19]. Similar observations were reported in Mozambique where weak referral and documentation systems negatively affected continuity of PMTCT care among pregnant women living with HIV [23]. Effective patient tracking mechanisms remain important for identifying women who miss appointments and ensuring continuity of viral load monitoring throughout pregnancy and breastfeeding.

At the community level, HIV-related stigma remained one of the most consistently reported barriers affecting adherence and continuity of PMTCT services in Cameroon [6]. Fear of disclosure, discrimination, and social rejection discouraged many women from openly participating in HIV care programs or attending clinics regularly. Similar findings were reported in South Africa where stigma negatively affected adherence to ART among pregnant women living with HIV [19]. Comparable evidence from sub-Saharan Africa also identified stigma and fear of disclosure as important barriers affecting PMTCT uptake and retention in care [20]. In Uganda and Nigeria, studies similarly reported that women who feared negative reactions from partners and relatives were more likely to interrupt treatment or avoid clinic attendance [24, 25]. Research conducted in Côte d'Ivoire equally found that community discrimination and fear of disclosure significantly reduced retention in HIV care among pregnant women enrolled in PMTCT services [26]. Persistent HIV-related stigma therefore continues to undermine continuity of HIV care despite improvements in HIV awareness and availability of treatment services.

Low male partner involvement was another important issue identified in the reviewed studies. Women who lacked emotional, social, or financial support from partners were more likely to miss appointments and experience treatment interruption during pregnancy and breastfeeding [10]. Similar findings were reported in sub-Saharan African PMTCT programs where male partner involvement significantly improved adherence to treatment and continuity of HIV care [13]. Studies conducted in Kenya and Malawi equally demonstrated that women who received support from partners were more likely to maintain regular clinic attendance and complete recommended PMTCT follow-up schedules [5, 16]. Similar observations were reported in Rwanda where supportive male involvement improved adherence to ART and retention among women enrolled in PMTCT services [27]. Lack of partner support may therefore increase emotional stress and reduce women's ability to remain fully engaged in long-term HIV care.

Economic hardship and transportation difficulties also emerged as important structural barriers affecting viral load follow-up in Cameroon [9]. Women living in rural and remote communities often experienced difficulties accessing healthcare facilities because of long travel distances and transportation costs. Similar findings were documented in Kenya where geographical inaccessibility negatively affected continuity of HIV care among women enrolled in PMTCT services [12]. Comparable studies conducted in rural Ethiopia and Tanzania reported that repeated clinic visits created financial burdens for women receiving ART and contributed to

missed appointments and poor retention in care [16, 18]. Research from rural Malawi also demonstrated that poverty and transport limitations reduced clinic attendance and continuity of PMTCT follow-up among women living with HIV [28]. Poverty therefore continues to influence healthcare-seeking behavior and continuity of viral load monitoring among pregnant and breastfeeding women living with HIV.

The review also identified cultural beliefs and misconceptions regarding HIV treatment as barriers affecting adherence among some women in Cameroon [15]. In certain communities, misinformation regarding ART use during pregnancy and reliance on traditional medicine contributed to treatment interruption and inconsistent clinic attendance. Similar findings were reported in Ghana where traditional beliefs and alternative healing practices influenced treatment-seeking behavior among individuals living with chronic illnesses [1]. Comparable observations were equally reported in Nigeria where sociocultural beliefs affected adherence to HIV treatment among women enrolled in PMTCT programs [25]. Studies conducted in rural Uganda also found that misconceptions regarding HIV treatment contributed to inconsistent clinic attendance and poor adherence among pregnant women receiving ART [29]. These findings suggest that sociocultural realities remain important considerations in PMTCT implementation and continuity of HIV care within African settings.

Despite these challenges, the review strongly demonstrated the positive contribution of community-based support systems in improving PMTCT outcomes and viral load follow-up in Cameroon. Mentor mother programs were consistently associated with improved adherence, psychosocial support, and retention in care among pregnant and breastfeeding women living with HIV [7]. Similar findings were reported in Malawi where mentor mother interventions improved clinic attendance and adherence to ART among women enrolled in PMTCT services [16]. Community health workers and peer educators also contributed positively through home visits, appointment reminders, counseling, and tracing of women who missed scheduled clinic visits [5]. Comparable findings were reported in Zimbabwe where community support interventions strengthened continuity of HIV care and improved retention among women receiving ART [30]. Studies conducted in Kenya additionally found that peer support interventions improved adherence and encouraged continuity of PMTCT care among women receiving HIV treatment services [31]. These findings support the growing importance of community-centered approaches in strengthening PMTCT outcomes within resource-limited settings.

Community support groups were equally identified as important platforms for emotional support, health education, and experience sharing among women living with HIV. Participation in peer support groups helped reduce feelings of isolation and encouraged women to continue treatment during pregnancy and breastfeeding. Mobile phone reminders and follow-up calls were additionally identified as useful approaches for improving appointment adherence and continuity of HIV care [31]. Similar findings were reported in Kenya where mobile health interventions improved clinic attendance and retention among women receiving HIV treatment services [31]. These findings suggest that low-cost community-centered interventions may significantly improve continuity of viral load monitoring within PMTCT programs.

Another important finding from this review relates to the impact of insecurity and armed conflict on PMTCT follow-up in Cameroon. Conflict in the North West and South West Regions disrupted access to maternal and HIV healthcare services because of displacement, road insecurity, and temporary closure of health facilities [5]. Similar findings were reported

among conflict-affected populations in sub-Saharan Africa where insecurity negatively affected continuity of HIV care among pregnant and breastfeeding women living with HIV [14]. Women living in insecure communities were more likely to miss clinic appointments, interrupt treatment, and experience poor continuity of viral load monitoring. Insecurity also reduced the ability of healthcare workers and community support teams to conduct outreach activities, home visits, and patient follow-up within affected communities.

The findings from this review have important implications for HIV policy and PMTCT program implementation in Cameroon. Strengthening laboratory systems, improving viral load result turnaround time, increasing the number of trained healthcare workers, and strengthening patient tracking systems may improve continuity of care among pregnant and breastfeeding women living with HIV. Expanding mentor mother programs, community health worker follow-up, peer support interventions, and decentralized HIV services may further strengthen retention in care and improve adherence to ART within PMTCT programs.

This review also identified important research gaps within the Cameroonian context. There remains limited Cameroon-specific evidence directly examining viral load follow-up among pregnant and breastfeeding women living with HIV, particularly within conflict-affected regions. More implementation research is needed to evaluate the long-term effectiveness of community-based interventions on viral suppression outcomes, retention in care, and prevention of mother-to-child transmission of HIV in Cameroon. Future studies should additionally explore the role of digital health interventions, differentiated service delivery models, and decentralized HIV care approaches adapted to local realities within the country.

Overall, the reviewed evidence suggests that improving viral load follow-up within PMTCT programs in Cameroon requires both stronger healthcare systems and sustained community-based support mechanisms. Addressing health system weaknesses while strengthening psychosocial and community support interventions may contribute significantly to improved maternal HIV outcomes and reduction of mother-to-child transmission of HIV in Cameroon.

## Conclusion

This narrative review has shown that viral load follow-up among pregnant and breastfeeding women living with HIV in Cameroon continues to be influenced by several interconnected health system, social, economic, and conflict-related challenges. Delayed laboratory result turnaround time, shortage of trained healthcare personnel, weak patient tracking systems, transportation difficulties, HIV-related stigma, poor male partner involvement, and insecurity within conflict-affected regions all contribute to interruptions in continuity of PMTCT care and viral load monitoring. These barriers reduce retention in care and may negatively affect viral suppression outcomes among women enrolled in PMTCT services.

Despite these challenges, the review further demonstrated that community-based support systems remain important facilitators of continuity of care within PMTCT programs in Cameroon. Mentor mother programs, peer support groups, community health worker follow-up, adherence counseling, home visits, and mobile reminder interventions were consistently associated with improved clinic attendance, adherence to antiretroviral therapy, and retention in care among pregnant and breastfeeding women living with HIV. These interventions strengthen the connection between health facilities and communities while providing psychosocial and practical support to women receiving HIV care.

The findings from this review highlight the need for stronger investments in laboratory infrastructure, healthcare workforce strengthening, patient follow-up systems, and decentralized viral load monitoring services in Cameroon. Greater integration of community-based interventions into PMTCT programs may also improve continuity of care and contribute to better maternal and infant health outcomes. Particular attention should be given to conflict-affected and underserved communities where interruptions in healthcare services remain common.

This review also identified important research gaps within the Cameroonian context. There remains limited evidence directly evaluating long-term viral load follow-up and the effectiveness of community-based support interventions among pregnant and breastfeeding women living with HIV in Cameroon. Future research should focus on implementation studies, digital follow-up systems, differentiated HIV service delivery models, and strategies adapted to the realities of healthcare delivery within both stable and conflict-affected settings.

Overall, improving viral load follow-up within PMTCT programs in Cameroon will require synchronized efforts involving healthcare providers, policymakers, community structures, development partners, and affected communities. Strengthening both health systems and community-based support mechanisms may contribute significantly to sustained viral suppression and reduction of mother-to-child transmission of HIV in Cameroon.

## Conflict of Interest

The authors declares that there is no conflict of interest regarding the publication of this review article.

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## Ethical Approval

This study was conducted as a narrative review using information obtained from published scientific articles, reports, and publicly available documents. Since no human participants, patient records, or confidential information were directly involved in the study, ethical approval was not required.

## Data Availability

The information used to support the findings of this review was obtained from published articles, institutional reports, and publicly accessible sources cited within the manuscript. All relevant data are therefore available within the article and its reference list.

## Author Contributions

Egbe Derick Agbor conceived the study, carried out the literature search, synthesized the findings, and prepared the initial manuscript draft. Eyong Manyiyong Queenta contributed to the design of the review, critical revision of the manuscript, and overall academic supervision. Fietsop Ernestine Nkemta, Frida Bessem Taku Bate, and Eyong Bessemeyong Velda contributed to the interpretation of findings, manuscript review, and editing of the final version. All authors read and approved the final manuscript before submission.

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# From Black Box to Boardroom: The Significance of Explainable AI (XAI) in Reducing Algorithmic Risk and Rebuilding Confidence in Digital Payment Systems

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***Abstract*** *The wide implementation of advanced Machine Learning (ML) models in digital payment systems, especially for fraud detection and credit risk assessment, has substantially improved operational efficiency and transaction security. The inherent opacity, often referred to as the black box character, of these high-performing algorithms poses considerable and mounting issues related to algorithmic fairness, stakeholder trust, and compliance with regulations. This article analyzes the growing strategic significance of Explainable Artificial Intelligence (XAI) as an important governance tool for mitigating algorithmic risk in financial services. The paper exposes how XAI, informed by Agency Theory and Institutional Theory, is not just a technical requirement but an essential institutional mechanism for ensuring regulatory accountability within frameworks like the EU AI Act, restoring public trust and identifying and alleviating systemic algorithmic bias in credit scoring and fraud risk assessment. A conceptual framework is introduced and it illustrates how XAI; using post-hoc interpretation methods such as SHAP (SHapley Additive exPlanations) and LIME (Local Interpretable Model-agnostic Explanations)- bridges the knowledge disparity between intricate AI models and various human stakeholders, including customers, fraud analysts, and regulators. This transformation shifts AI from a hypothetical institutional liability to a responsible, auditable, and governable asset within the digital payment ecosystem. The report concluded by describing key areas for forthcoming empirical research on the organizational problems associated with XAI implementation across various regulatory jurisdictions.*

***Keywords*** *Agency Theory, Algorithmic Bias, Algorithmic Risk, Digital Payments, Explainable Artificial Intelligence (XAI), Institutional Theory, Machine Learning Opacity.*

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## Introduction

Empirically, the digital payment ecosystem has witnessed an unparalleled structural disturbance over the last decade, with Artificial Intelligence (AI) and Machine Learning (ML) now enabling real-time decision-making across billions of daily transactions [1]. Algorithmic systems have now become the operational foundation of modern financial services, incorporating dynamic transaction routing, credit risk assessment, fraud detection, and anti-money laundering compliance. AI-driven fraud detection systems reveal significant performance benefits, achieving average detection accuracy rates of 94.2% compared to 78.5% for rule-based systems, and decreasing false positive rates from 12.3% to 4.7% [2]. Deep learning architecture has proven the ability to identify intricate, non-linear fraud patterns that completely evade traditional threshold-based techniques.

However, the sophistication that grants commercial power to these models concurrently renders them institutionally perilous. Deep neural networks, gradient boosting ensembles, and other high-performing machine learning architectures are fundamentally opaque; their core decision-making logic; the specific combination of weighted inputs that yields a particular output- is not readily explainable by human operators, developers, or regulators. This opacity is the defining feature of what is now commonly known as the black box problem [3]. For financial services, where AI determinations affect individuals' payment account security, credit access, and participation in the formal economy, the incapability to clarify, audit, or challenge algorithmic decisions represent a major governance failure.

The dilemma referred to as black box arises across three major institutional risk dimensions in digital payment systems. At first, it weakens customer trust: especially customers whose valid transactions are rejected or whose accounts are suspended by AI-based fraud detection systems are unable to challenge decisions they cannot comprehend, resulting in frustration, reputational harm for the institution, and possible regulatory grievances [4]. Secondly, it engenders regulatory exposure: where financial institutions are increasingly subjected to statutory and supervisory directives; most notably under the EU AI Act, Consumer Financial Protection Bureau (CFPB) frameworks in the United States, the Payment Systems Regulator in the UK, and analogous entities worldwide; necessitating the ability to furnish clear, auditable justifications for automated high-impact decisions. Third, it exacerbates the risk of algorithmic bias: non-transparent models trained on historically biased data can insidiously sustain and intensify discriminatory patterns in credit access, fraud detection [5], and risk assessment, resulting in outcomes that amount to digital redlining, with no institutional entity able to identify the underlying mechanism [6].

This paper presents the subsequent additions to the literature. The approach utilizes Agency Theory and Institutional Theory to explain that the deployment of explainable AI (XAI) in financial services is not solely a technical choice but an institutional necessity. It offers a systematic conceptual framework illustrating how XAI techniques- like SHAP and LIME convert AI opacity into tailored explanations that address the unique accountability requirements of customers, fraud analysts, and regulatory auditors. An operational taxonomy of the three principal algorithmic risk types that XAI directly alleviates is presented within digital payment systems. It delineates the priority research inquiries that ought to direct empirical exploration of XAI implementation issues across various organizational and regulatory environments.

The following sections of this paper are structured as follows. The Theoretical Framework section defines the foundations of Agency and Institutional Theory as they relate

to XAI as a governance mechanism. The Materials and Methods section describe conceptual and literature-based research methodology. The Results section defines the XAI methodologies and the stakeholder explanation structure. The Discussion section examines how XAI alleviates categories of algorithmic risk. The Conclusion portrays potential avenues for investigation.

## Theoretical Framework

### Explainable Artificial Intelligence as a Governance Instrument

The necessity for XAI governance in financial services is essentially based on two complementary organizational theories: Agency Theory and Institutional Theory. Collectively, these frameworks reveal that the adoption of XAI is not merely a voluntary technical expenditure but an essential structural requirement for any financial institution implementing high-stakes algorithmic decision-making systems.

### Agency Theory and Algorithmic Accountability

As rooted in the seminal research of Jensen and Meckling [7], the Agency Theory investigates the dynamics between *principals*; individuals who confer decision-making power as well as *agents*; individuals who apply such power on behalf of the principal. The theory delineates the circumstances in which information asymmetry between principals and agents engenders governance risks, such as moral hazard (agents engaging in actions misaligned with principal interests due to insufficient oversight) and adverse selection (principals unable to differentiate between responsible and irresponsible agents due to informational deficiencies).

A multifaceted principal-agent impasse exists within AI-enabled digital payment systems. Customers are seen as principals whose financial transactions and service access are governed by AI agent systems, with no transparency. Regulators are authorities that have entrusted financial institutions with the operational duty of ensuring equitable and non-discriminatory decision-making yet are unable to ascertain compliance when algorithms lack transparency. In financial institutions, boards and senior management serve as principals whose strategic and ethical responsibilities are carried out by AI development teams, whose model designs may be opaque to non-technical leadership.

Black-box AI systems exemplify a significant principal-agent information imbalance. The agent (the AI system and its operators) makes judgments based on reasoning that is opaque to the stakeholders affected by those decisions (customers) and to those responsible for ensuring their fairness and legality (regulators and institutional leadership). This asymmetry creates the moral hazard and adverse selection conditions identified by Agency Theory as governance failures: institutions may utilize models with acknowledged bias risks due to opacity hindering detection, and regulators are unable to differentiate between responsible and irresponsible AI governance without transparency mechanisms [8].

XAI directly addresses this principal-agent information asymmetry. By producing comprehensible elucidations of AI decision rationales; pertaining to individual prediction instances for customers, feature significance and model behavior for analysts, and systematic audit trails for regulators; XAI reinstates the informational transparency deemed crucial for effective governance by Agency Theory. It alters the principal-agent relationship from one defined by ambiguous delegation to one regulated by responsible transparency, allowing principals at all levels to have significant monitoring over agent conduct [9].

### Institutional Theory and Regulatory Isomorphism

Institutional Theory, as articulated by DiMaggio and Powell [10] in their seminal examination of organizational isomorphism, provides a supplementary framework for comprehending the institutional factors influencing the adoption of XAI. The theory suggests that organizations within similar institutional fields tend to adopt structurally similar practices through three isomorphic mechanisms: coercive isomorphism (adoption prompted by regulatory or legal mandates), normative isomorphism (adoption influenced by professional standards and industry norms), and mimetic isomorphism (adoption motivated by competitive imitation of perceived best practices).

All these three isomorphic mechanisms concurrently function to propel XAI adoption within financial organizations. Coercive isomorphism is the most potent: the EU AI Act's classification of credit scoring as a high-risk AI application, the CFPB's guidance on automated decision-making, and the Basel Committee's nascent principles regarding operational risk from AI systems collectively establish a coercive regulatory framework wherein the ability to elucidate algorithmic decisions is evolving into a legal compliance obligation rather than a discretionary governance improvement. Normative isomorphism functions through the developing professional standards of financial risk management, which progressively integrate algorithmic fairness and explainability as fundamental abilities [11]. Mimetic isomorphism propels adoption when prominent companies, such as JPMorgan, HSBC, and Mastercard; openly articulate their XAI governance frameworks, generating competitive pressure on rivals to exhibit comparable proficiency.

The institutional theory viewpoint highlights a critical aspect of XAI adoption that technical analyses overlook; institutions adopt XAI not merely for its technical superiority, but because XAI governance imparts institutional legitimacy; the perception among regulators, customers, and the general public that the institution is functioning responsibly within established normative and legal frameworks [10]. In a time of increasing public apprehension regarding algorithmic fairness and AI responsibility in financial services, the institutional legitimacy aspect of XAI adoption holds strategic importance in its own right, irrespective of any direct performance advantages.

## Materials and Methods

This paper utilizes a conceptual research methodology, systematically referencing established theoretical literature in Agency Theory, Institutional Theory, and Explainable AI, alongside a structured review of empirical evidence regarding XAI techniques and their governance applications in financial services. The conceptual framework aligns with the paper's main objectives: to develop a theoretically based governance structure for XAI in digital payment systems and to delineate the methods by which XAI strategies mitigate recognized algorithmic risk categories. This methodology aligns with established practices in financial services governance research, where conceptual frameworks based on theoretical foundations are recognized as a valuable scholarly contribution [12].

A systematic search of academic databases, including Scopus, Web of Science, and IEEE Xplore, was conducted for the literature review, augmented by an examination of practitioner publications from regulatory entities such as the European Commission, the Financial Stability Board, and the Bank for International Settlements. Search terms comprised: explainable artificial intelligence, XAI in financial services, SHAP in payment systems, LIME in fraud detection, algorithmic bias in finance, Agency Theory in AI governance, and

Institutional Theory in fintech. The inclusion requirements are as follows: (1) direct relevance to AI/ML transparency, governance, or fairness in financial services; (2) publication or release between 2017 and 2025; and (3) adequate methodological and empirical quality to facilitate conceptual framework development. A total of 47 sources satisfied the inclusion criteria and contributed to the framework outlined in this study.

The conceptual framework was created through a repetitive process of theoretical integration and practical examination. The foundations of Agency Theory and Institutional Theory were formed initially, subsequently leading to the alignment of specific XAI methodologies with the governance functions delineated by each theoretical perspective. The stakeholder explanation taxonomy was established by analyzing the specific accountability requirements of the three main user categories; customers, fraud analysts, and regulators as delineated in the empirical literature on AI governance within financial services. The algorithmic risk taxonomy was developed by systematically linking recorded risk types to XAI mitigation capabilities.

## Results

### XAI Techniques Applicable to Digital Payment Systems

Effective fraud detection and credit risk models utilized in digital payment systems generally incorporate deep neural networks, gradient boosting algorithms, and ensemble techniques. These structures yield enhanced predictive accuracy because to their ability to simulate intricate, non-linear interactions among numerous input features; interactions that simpler, inherently interpretable models like logistic regression or decision trees cannot sufficiently capture. This performance-interpretability trade-off indicates that the models most efficient for payment security are concurrently the least transparent. Post-hoc explanation methods; XAI techniques that function on a trained model without altering its architecture are thus the principal practical means of attaining interpretability in deployed payment AI systems [3].

### Local Interpretable Model-Agnostic Explanations (LIME)

LIME, developed by Ribeiro et al. [13], produces localized explanations for individual model predictions by approximating the sophisticated black-box model's behavior in the vicinity of a particular data instance using a simpler, interpretable surrogate model. The technique modifies the input features of a specific transaction, monitors the alterations in the black-box model's output due to these modifications, and constructs a locally linear model to represent this local behavior. The coefficients of this surrogate model offer a comprehensible approximation of the features that were most significant in influencing the model's choice for that particular instance.

In the realm of a payment fraud detection system, LIME can elucidate a specific declined transaction as follows: 'This transaction was identified as high-risk primarily due to (1) its origin from a novel IP address not previously linked to this account [contribution weight: 0.42], (2) its occurrence at 02:14 AM local time, outside the account's customary transaction timeframe [weight: 0.31], and (3) its association with a merchant category not previously documented in this account's transaction history [weight: 0.18].' This explanation is readily comprehensible for a customer seeking to understand and contest a payment denial, while also supplying a fraud analyst with the precise feature information necessary to validate or override the model's determination.

### Shapley Additive Explanations (SHAP)

SHAP, created by Lundberg and Lee [14], is based on the Shapley value framework of cooperative game theory, offering a more theoretically robust and globally coherent

method for attributing feature importance. SHAP values allocate a contribution score to each input feature, indicating its marginal effect on the model's prediction, determined by the average marginal contribution of that feature across all potential permutations of features. Compared to LIME, which offers mainly local approximations, SHAP adheres to three mathematically advantageous axiomatic properties: local accuracy (the aggregate of SHAP values corresponds to the model's prediction), missingness (features not present in an instance are assigned zero attribution), and consistency (a feature's SHAP value rises if its marginal contribution increases across different model versions).

In a payment fraud detection application, SHAP offers instance-level explanations by pinpointing the specific transaction features that significantly influenced a particular decision toward fraud classification, as well as model-level insights through aggregated SHAP value distributions that indicate which features are consistently the most influential across the entire transaction population. This capability is especially beneficial for regulatory audits and bias detection, as it can identify whether proxies for protected attributes (such as geographic location codes associated with demographic traits) are among the primary systematic influences on fraud classification decisions within the population.

## Stakeholder-Differentiated Explanation Framework

The efficacy of XAI governance in payment systems is fundamentally contingent upon the idea that explanations must be tailored to the information requirements, technical proficiency, and accountability expectations of the particular stakeholder receiving them. A singular global explanatory format fails to sufficiently address any of these audiences. Table 1 delineates the structured XAI explanation framework, correlating each stakeholder group with their fundamental governance requirement, the suitable explanation style, and the particular XAI technique most adept at producing it.

**Table 1.** Stakeholder-Differentiated XAI Explanation Framework for Digital Payment Systems

| Stakeholder | Governance Requirement | Explanation Format | Primary XAI Technique | Example Output |
|---|---|---|---|---|
| Customer / Account Holder | Trust and Recourse: Ability to understand, contest, and seek remedy for automated decisions affecting financial access | Plain-language natural language explanation of the primary decision factors | LIME (local, instance-level approximation) | Your payment was declined because it originated from an unrecognized location after midnight and the amount exceeded your typical transaction range. |
| Fraud Analyst / Risk Manager | Operational Efficiency: Ability to efficiently validate model decisions, prioritize alert queues, and provide model improvement feedback | Feature importance scores and confidence intervals for flagged transactions; model decision boundary visualizations | SHAP (instance-level and aggregated feature contribution values) | Transaction flagged: location score +0.42, time anomaly +0.31, merchant category +0.18, transaction amount +0.09. Confidence: 0.87. |
| Regulator / Compliance Auditor | Accountability and Fairness: Verifiable evidence that | Systematic feature contribution audit logs; demographic | Aggregated SHAP analysis; model card | Fraud classification rate by demographic group: Group A 3.2%, Group B |

| | | | | |
|---|---|---|---|---|
| | automated decisions are non-discriminatory, legally compliant, and auditable | parity metrics; population-level SHAP distribution analysis | documentation; algorithmic impact assessments | 3.4%, Group C 3.1% — within 0.5pp parity threshold. Top systematic feature: transaction velocity (SHAP mean 0.38). |
| Board / Senior Management | Strategic Governance: Confidence that AI systems align with institutional values, regulatory obligations, and risk appetite | Executive-level AI governance dashboards; model performance and fairness KPI reporting; XAI audit completion status | Model cards; governance reporting frameworks; board-level AI risk metrics | Q3 AI Governance Dashboard: Fraud model accuracy 94.2%; false positive rate 4.7%; fairness audit completion 100%; regulatory inquiry response time: 2.1 days average. |

## Algorithmic Risk Taxonomy and XAI Mitigation Mechanisms

XAI governance mechanisms directly address three key areas of algorithmic risk in digital payment systems. Table 2 delineates the risk taxonomy alongside the associated XAI mitigation strategies and performance metrics.

**Table 2.** Algorithmic Risk Taxonomy and XAI Mitigation Mechanisms in Digital Payment Systems

| Risk Category | Definition and Mechanism | Consequence if Unmitigated | XAI Mitigation Approach | Key Performance Indicator |
|---|---|---|---|---|
| Algorithmic Bias | Systematic, repeatable discriminatory outcomes arising from biased training data, proxy variable encoding of protected attributes, or model architecture choices that disproportionately disadvantage specific demographic groups | Digital redlining in credit access; discriminatory fraud flagging disproportionately affecting minority customers; regulatory sanctions and reputational damage | SHAP population-level analysis to identify protected attribute proxies; demographic parity testing across model outputs; iterative debiasing through feature removal and retraining | Demographic fraud flag rate disparity < 1 percentage point; proxy variable SHAP contribution < 5% of total model decision weight |
| False Positive Proliferation | High rates of legitimate transactions incorrectly classified as fraudulent by overly conservative ML models, generating customer friction, operational costs, and revenue loss | Customer abandonment; increased customer service costs; competitive disadvantage; erosion of customer lifetime value | LIME instance-level explanations enabling rapid analyst validation and override of false positive decisions; feedback loops from override decisions to model retraining | False positive rate < 5%; analyst validation time per flagged transaction < 90 seconds; model retraining cycle incorporating override feedback < 30 days |

| | | | | |
|---|---|---|---|---|
| Regulatory Non-Compliance | Inability to provide legally required explanations for automated high-impact decisions, exposing institutions to regulatory sanctions, fines, and operational restrictions | Regulatory fines; operating license restrictions; mandatory model shutdown orders; reputational damage from public enforcement actions | Audit-ready SHAP documentation; standardized explanation logs retained for regulatory review; automated compliance reporting frameworks aligned to EU AI Act, CFPB, and FCA requirements | Regulatory explanation request response time < 48 hours; audit log completeness 100%; zero regulatory enforcement actions related to algorithmic explainability |

## Conceptual Framework: From Black Box to Transparent Asset

Table 1 illustrates the transition from black-box AI liability to visible, governable AI asset within the digital payment system, synthesizing the theoretical foundations and technical capabilities of XAI outlined above. The framework functions through three consecutive stages: Opacity (the pre-XAI condition), Explanation Generation (the XAI intervention), and Governed Transparency (the post-XAI institutional result).

During the Opacity stage, high-performing machine learning models produce prediction outputs devoid of transparent decision rationales. The governance implications encompass the three risk categories outlined in Table 2: undiscovered algorithmic bias, generation of false positives without actionable analyst guidance, and regulatory non-compliance due to the inability to audit choices. During the Explanation Generation phase, post-hoc XAI methodologies (LIME and SHAP) are utilized to convert opaque model outputs into explanations tailored for stakeholders at both the individual instance level (for specific transaction decisions) and the population level (for comprehensive governance analysis). During the Governed Transparency phase, the institutional outcomes include restored customer trust via clear and contestable decisions; improved operational efficiency through analyst-accessible feature importance data; and regulatory compliance through auditable documentation of fairness-verified decisions.

The paradigm distinctly establishes XAI as an institutional governance layer that functions above and surrounding the AI model, serving not as a modification to the model's architecture, but as a systematic accountability infrastructure that transforms model outputs into regulated decisions. This posture is essential as it allows for the implementation of XAI governance regardless of the underlying model's architecture, so maintaining the performance benefits of intricate ML systems while incorporating the accountability mechanisms necessary for institutional and regulatory legitimacy.

# Discussion

## XAI as Strategic Risk Management, Not Compliance Overhead

The prevailing perception of XAI in professional settings is as a regulatory compliance obligation; a financial burden mandated by authorities that organizations must endure to retain their operational licenses. This framework is strategically deficient and empirically erroneous. Evidence from institutions that have extensively implemented XAI, such as Mastercard's Decision Intelligence framework and JPMorgan's model risk governance architecture, indicates that XAI yields favorable commercial returns across various dimensions that significantly surpass its implementation costs [15].

The commercial return channels are threefold. One, XAI-enabled reduction of false positives directly enhances customer retention and lifetime value, as each false positive leading to an unwarranted payment decline or account suspension signifies a potential termination of customer relationships, with acquisition costs for digital banking customers varying from $150 to $400 per customer [16]. Secondly, the efficiency improvements for analysts resulting from SHAP-driven alert prioritization diminish the operational expenses associated with fraud investigations: organizations utilizing SHAP-based alert triage report reductions in analyst investigation time of 40-60%, generating significant cost savings at scale [2]. IBM's deployment evidence [17] reveals that these efficiency gains compound over time as model retraining cycles incorporate analyst override feedback, progressively reducing the false positive burden. Third, the institutional legitimacy advantages of verifiable XAI governance diminish the regulatory risk premium incorporated in the capital cost for AI-centric financial firms, as oversight diminishes and regulatory assurance escalates [5, 20].

The Agency Theory approach enhances this strategic value evaluation. XAI mitigates the moral hazard risk associated with black-box AI implementation: when model developers and risk managers are aware that the decisions of their algorithmic systems will undergo XAI-generated examination by analysts, auditors, and regulators, the incentive framework transitions towards more prudent and fairness-oriented model development. XAI serves as an institutional oversight tool that regulates the principal-agent dynamic between institutional leadership and AI development teams, fulfilling a governance role that holds value beyond its immediate technical results. Barney's [22] resource-based view confirms that this XAI-generated institutional knowledge constitutes a strategic asset that is genuinely difficult for competitors to replicate: it combines proprietary training data, organisation-specific explanation calibration, and accumulated model governance expertise in ways that cannot be purchased off-the-shelf.

## Addressing Algorithmic Bias Through XAI

The algorithmic bias aspect of XAI governance warrants specific focus inside payment systems, as its implications are both challenging to identify and significantly impactful legally and reputationally. Mehrabi et al. [6] identify various forms of bias that may infiltrate machine learning systems via training data, feature selection, and model architectural decisions. In payment fraud detection, the predominant bias mechanism is proxy variable encoding: models developed on historical fraud data may utilize geographic location, device type, or transaction merchant categories as predictive features, each of which can correlate with demographic characteristics that are legally protected bases for financial service decisions. ResearchGate [18] documents that proxy variable bias was the most frequently cited cause of regulatory enforcement actions against AI-driven financial services systems globally between 2020 and 2024.

The issue is that these proxy correlations are obscured in model outputs: a fraud detection model may yield statistically accurate predictions at the population level while concurrently exhibiting disproportionately elevated false positive rates for particular demographic groups, with no indication in its overall performance metrics disclosing this discrepancy. This state is specifically identified by Institutional Theory as the governance failure of black-box legitimacy: institutions exhibit the facade of compliance through elevated model accuracy, while the mechanisms of discriminatory impact remain obscured [10].

Johnson et al. [19] argue that this structural invisibility problem is the primary reason why regulatory frameworks mandating

explainability, rather than merely outcome fairness are necessary: outcome-only monitoring cannot detect the mechanism of discrimination, only its symptoms.

By analyzing SHAP value distributions among demographic subgroups within the transaction population, institutions can ascertain if particular attributes are systematically influencing fraud categorization choices differently across groups, hence revealing the statistical signature of proxy variable bias. When this signature is identified, the XAI evidence base facilitates focused debiasing measures: elimination of the recognized proxy features, reweighting of training data to address demographic underrepresentation, or regularization constraints that restrict the influence of potentially discriminatory features on final model outcomes [6].

Number Analytics [25] reports that institutions using systematic SHAP-based bias auditing detected and corrected an average of 3.2 proxy variable issues per model prior to production deployment issues that had passed standard accuracy-based validation.

## Regulatory Trajectory and the First-Mover Governance Advantage

The regulatory path for AI explainability in financial services is distinctly moving towards greater specificity and stricter enforcement. The EU AI Act of 2024, mandates legally obligatory explainability standards for AI systems used in credit scoring and fraud detection, imposing penalties for non-compliance of up to 3% of global annual revenue [5]. The Consumer Duty UK Financial Conduct Authority, enacted in 2023, establishes operational responsibilities for enterprises to prove that automated decision-making systems yield favorable customer outcomes; a criterion that is largely unascertainable without explainable artificial intelligence (XAI) capabilities. The 2023 guideline from the US Consumer Financial Protection Bureau on automated decision-making in credit clearly delineates customers' entitlement to get meaningful, actionable reasons for unfavorable credit judgments, irrespective of whether such decisions were rendered by algorithmic systems. Johnson, Martinez, and Thompson [19] project that by 2028, all G20 jurisdictions will have enacted some form of AI explainability requirement for financial services, making current first-mover XAI investments increasingly valuable as the regulatory landscape converges.

Institutions that have proactively invested in XAI governance infrastructure prior to these legislative mandates are poised to gain a significant first-mover advantage in three key areas. Initially, they encountered reduced compliance expenses as their XAI architecture was developed for governance objectives rather being adapted to satisfy certain regulatory requirements. Secondly, they amass operational experience in XAI that provides a learning advantage: discerning the most effective explanation formats for various stakeholder audiences, identifying operationally actionable bias detection thresholds, and determining the most efficient model retraining cycles to address identified bias gaps cannot be quickly acquired and represents institutional knowledge that evolves only through continuous practice. Third, they are poised to collaborate proactively with regulators as partners in formulating AI governance standards, rather than only responding to supervisory oversight; this relational orientation offers long-term advantages in supervisory relationships [5]. Intersog [24] documents that institutions classified as XAI-advanced by supervisory authorities faced 47 percent fewer regulatory requests for information regarding algorithmic decision-making compared to their non-XAI peers in 2024.

### Limitations and Future Research Directions

This work identifies three shortcomings of the conceptual approach that require attention in future empirical research. The proposed framework is theoretical and conceptual, lacking empirical validation; it delineates the mechanisms by which XAI is expected to yield governance advantages based on theoretical reasoning and case studies, yet it does not provide primary data regarding the extent or uniformity of these benefits across various institutional and regulatory environments. Future research should utilize mixed-methods designs to empirically evaluate the framework propositions, assessing XAI adoption outcomes in relation to false positive reduction, bias detection efficacy, and regulatory compliance efficiency across various institutional sizes, AI maturity levels, and geographic regulatory contexts [12].

The research examines post-hoc explanation approaches, specifically LIME [13] and SHAP [14], relevant to implemented black-box models. This framework does not address the significant and expanding literature on intrinsically interpretable models, including architectures like explainable boosting machines, monotonic neural networks, and concept bottleneck models, which trade some predictive performance for inherent transparency. Future research should examine if innately interpretable models may attain satisfactory performance levels for payment fraud detection, perhaps providing a governance solution that eliminates the need for a post-hoc explanation layer [17]. Practitioner perspectives are gotten from prominent Chief Risk Officers (CRO) of financial institutions on this matter via qualitative interview research [19].

The organizational challenges of implementing XAI deployment include the technical intricacies of incorporating SHAP and LIME pipelines into operational ML systems, the privacy issues linked with the increased data logging necessary for audit trails, and the cost-accuracy trade-offs in sustaining explainability infrastructure during model retraining cycles are recognized as critical areas for empirical research [18, 20].

## Conclusion

A theoretically based governance framework for Explainable AI (XAI) in digital payment systems is established by this research. It illustrates the shift from opaque black-box AI to transparent, auditable algorithmic governance is both strategically beneficial and institutionally essential. The Agency Theory analysis indicates that black-box AI systems generate a significant principal-agent information asymmetry that compromises governance relationships among customers, institutions, and regulators; an asymmetrical analysis that explainable AI (XAI) effectively addresses by reinstating the transparency necessary for functional accountability [7, 8]. The Institutional Theory analysis reveals that the adoption of XAI is influenced by three isomorphic mechanisms: coercive regulatory mandates [5, 19]., normative professional standards, and simulated competitive pressures [24]. Furthermore, XAI governance provides institutional legitimacy that possesses strategic value beyond its direct technical advantages [5].

The stakeholder-differentiated explanation framework outlined in Table 1 demonstrates that the efficacy of XAI governance relies on tailoring explanation formats to the specific accountability requirements of customers [4, 23], fraud analysts, regulators, and institutional leadership [21, 22]; a design principle that transforms XAI from a generic transparency mechanism into a focused institutional governance instrument. Table 2 presents an algorithmic risk taxonomy that correlates the three principal risk categories algorithmic bias [6, 18, false positive proliferation, and regulatory non-compliance

[5, 19, 20]: with designated XAI mitigation mechanisms and quantifiable performance indicators, thereby offering institutions a practical framework for the implementation of XAI governance.

This analysis concludes that financial institutions perceiving XAI just as a compliance burden are fundamentally underestimating its role in mitigating institutional risk, enhancing operational efficiency, and improving competitive posture [15, 22]. The institutions that will most effectively govern AI in the next decade are those that have commenced the process of ensuring their algorithmic systems are not only accurate but also accountable — not only powerful but also trustworthy. XAI serves as the institutional framework facilitating such journey. The inquiry now centers not on the necessity of XAI governance for financial institutions, but rather on their organizational resolve and technical capability to apply it prior to regulatory enforcement [5, 19], the erosion of client trust [4, 25], or algorithmic harm [6, 18] dictating their actions.

## Conflict of Interest

The author establishes that no financial, commercial, legal, or professional conflicts of interest exist that could have impacted on the design, analysis, or reporting of this research. The opinions articulated in this document are solely those of the author in an academic context and do not reflect the official stance of First City Monument Bank Limited or any associated organization.

## Ethical Approval

This work is a conceptual research article based solely on publicly accessible academic literature and published practitioner material. No primary data collection involving human subjects was undertaken in the creation of this paper. Accordingly, no official institutional ethical approval was required. This paper is part of a bigger doctorate research program that has obtained ethical clearance from the Texila American University Research Ethics Committee (Reference: TAU-REC-2024-0147). All forthcoming empirical research based on this approach will adhere strictly to institutional ethical principles, encompassing informed permission, data anonymization, and compliance with relevant data protection rules.

## Data Availability

There is no new primary dataset generated or analyzed for this paper. All requisite quantitative performance benchmarks, compliance metrics and empirical claims presented in this paper are derived from publicly available secondary sources including academic journal articles, regulatory authority publications, and institutional practitioner reports, all fully cited and referenced in the References section. Particularly, fraud detection performance benchmarks are drawn from Chen and Williams [2] and IBM [17]; bias and fairness statistics are referenced from Mehrabi et al. [6] and ResearchGate [18]; regulatory compliance data are drawn from Garcia and Thompson [5] and Johnson et al. [19]; commercial XAI deployment performance data are sourced from Quantiphi [15], McKinsey [16], Deloitte [20], Intersog [24], and Number Analytics [25]. All referenced sources are publicly accessible through their institutional websites or academic databases. The author confirms that there are no data access restrictions and no proprietary datasets underpinning any analytical claim in this paper.

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## Author Contributions

Temitope Onibaniyi is responsible for the contextual formulation of the theoretical framework, literature review, design and synthesis of the framework, drafting of the original paper, and adaptation of the final manuscript based on reviewer comments.

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# Social Health Insurance in Ethiopia: A Synthesis of Evidence on Willingness to Enroll, Institutional Preparedness, Fiscal Space, and Service Readiness as a Platform for Policy Action

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***Abstract*** *Ethiopia enacted Proclamation No. 690/2010 establishing a Social Health Insurance (SHI) scheme for formal sector employees, yet the program has remained non-operational for over fourteen years. With the government renewing its resolve to launch SHI and the National Health Compact (2025) projecting a doubling of the government health financing share by 2030, a consolidated review of current evidence is urgently needed. This narrative review synthesizes published evidence on four dimensions critical to SHI implementation: willingness to join and pay (WTJ/WTP), institutional preparedness, fiscal space, and health service availability and readiness. Searches were conducted across PubMed/MEDLINE, Google Scholar, Scopus, and Hinari, supplemented by grey literature from the World Bank, WHO, ILO, UNICEF, and the Ethiopian Ministry of Health, covering January 2010 to April 2025. Pooled WTP for SHI among the formal sector workforce was 42.25% for the broader formal sector in a 2023 meta-analysis (19 studies) and 49.62% for public civil servants in a 2024 meta-analysis, the divergence reflecting the populations pooled; average WTP stood at 1.6% of gross monthly income, well below the proposed 3% premium. Willingness to join ranged from 47.5% to 74% across settings, moderated by income, knowledge, quality perceptions, and provider network scope. Institutional readiness is constrained by gaps in EHIS claims management, ICT infrastructure, and strategic purchasing capacity. Fiscal space is restricted by a tax-to-GDP ratio of only 6.8% and persistent high inflation, although the National Health Compact signals new financing ambition. Service readiness in public facilities is critically low, with basic amenities available in only 39% and diagnostics in 40% of facilities. The four domains are deeply interconnected, and a launch that addresses WTP concerns without resolving service quality deficits will reproduce the same impasse that has persisted since 2010. Coordinated, evidence-informed reform across all four domains is a prerequisite for a viable and equitable SHI program in Ethiopia.*

***Keywords*** *Ethiopia, Fiscal Space, Health Financing Reform, Health Service Availability, Institutional Readiness, Social Health Insurance, Universal Health Coverage, Willingness to Pay, Willingness to Join.*

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## Introduction

Universal Health Coverage (UHC) is both a global health aspiration and a practical policy obligation. For Ethiopia, a country of more than 130 million people with one of the lowest per capita health expenditures in Sub-Saharan Africa, the pathway to UHC runs through two parallel health insurance tracks: Community-Based Health Insurance (CBHI) for the rural and informal sector population, and Social Health Insurance (SHI) for the formally employed workforce. While CBHI has expanded impressively since its 2011 pilot, reaching about 12.1 million households, covering roughly 87.4% of districts, by 2023 [1], the SHI scheme has remained non-operational since the promulgation of its founding proclamation in August 2010. The contrast is remarkable: one track of Ethiopia's dual-track insurance architecture has become one of the largest community health insurance programs in Africa, while the other has never processed a single enrollment.

The reasons for SHI's prolonged stall are well-rehearsed in the literature: a formal sector workforce reluctant to contribute the member-side 3% of gross salary (Proclamation No. 690/2010 sets a combined 6% premium, 3% from the employee and 3% from the employer, with 1% plus 1% for pensioners) for coverage they do not trust [2]; a public facility network whose quality falls short of member expectations; and persistent uncertainty about whether the institutional machinery needed to run a claims-based insurance scheme actually exists. What has been less systematically examined is the aggregate picture when these concerns are considered together. This review takes that integrated view, synthesizing evidence across four domains that, taken together, constitute the feasibility architecture of any SHI program: willingness to join and pay, institutional preparedness, fiscal space, and health service availability.

The review is motivated by a specific moment in Ethiopian health policy history. In 2024, the government formally proposed to introduce SHI [3]. The National Health Compact, endorsed in early 2025 with World Bank support, projects total health expenditure to grow from USD 4.8 billion in 2024 to USD 8.3 billion by 2030, with the government's share of health financing targeted to double from 27% to 53% [4]. The Health Insurance Strategic Plan II (HISP II) set a target of covering 100% of formal sector workers through SHI by 2025, a target that will not be met. In this context, a review that honestly appraises the current state of evidence across all four feasibility domains is not merely academic. It is a prerequisite for policy advocacy that is grounded in what the data actually say.

This paper proceeds as follows. Section 2 describes the review methodology. Section 3 presents the evidence on WTJ and WTP. Section 4 examines institutional readiness. Section 5 reviews fiscal space. Section 6 addresses health service availability and readiness. Section 7 synthesizes the cross-cutting policy implications. Section 8 presents advocacy recommendations. Sections 9 and 10 cover limitations and conclusions respectively.

## Review Methodology

This paper is structured as a narrative review, drawing on peer-reviewed literature, systematic reviews and meta-analyses, government policy documents, and reports from major multilateral and bilateral organizations. Narrative review was selected over systematic review as the most appropriate method for synthesizing evidence across heterogeneous domains (WTP studies, health systems capacity assessments, fiscal analysis, and facility surveys) that employ fundamentally different research designs and analytical frameworks. The approach mirrors the method used in landmark health financing reviews such

as those conducted for the WHO Health Financing Progress Matrix assessments.

The literature search covered the period from January 2010 to April 2025. Electronic databases searched include PubMed/MEDLINE, Google Scholar, Scopus, and Hinari (WHO Research for Health). Search terms were adapted for each domain: for WTP/WTJ, terms included 'willingness to pay,' 'willingness to join,' 'social health insurance,' 'formal sector,' and 'Ethiopia'; for institutional readiness, 'EHIS,' 'claims management,' 'strategic purchasing,' 'provider payment,' and 'health insurance capacity'; for fiscal space, 'fiscal space for health,' 'domestic resource mobilization,' 'government health expenditure,' and 'Ethiopia health financing'; for service availability, 'service availability and readiness assessment,' 'health facility readiness,' 'essential medicines,' 'health workforce,' and 'Ethiopia.'

In addition to indexed literature, grey literature was reviewed from the following sources: the Ethiopian Health Insurance Service (EHIS); the Federal Ministry of Health of Ethiopia; the World Bank Health, Nutrition and Population Practice; the WHO Ethiopia Country Office and WHO Headquarters Health Financing team; the International Labour Organization (ILO); UNICEF Ethiopia; the USAID Health Financing Improvement Program (HFIP); and Results for Development (R4D). Inclusion criteria required relevance to Ethiopia's SHI or CBHI program, publication in English, and a minimum of primary or secondary empirical content. Theoretical or purely opinion-based pieces without empirical support were excluded. A total of 64 sources were reviewed, including 31 peer-reviewed journal articles, 11 systematic reviews or meta-analyses, and 22 policy and program documents. The review is reported in line with the Scale for the Assessment of Narrative Review Articles (SANRA), addressing its core items: justification of the review's importance, statement of aims, description of the literature search, referencing of evidence, and scientific reasoning in the synthesis [5].

## Willingness to Join and Pay: What the Evidence Says

### Magnitude of Willingness to Join

Willingness to join (WTJ) and willingness to pay (WTP), while conceptually linked, capture distinct behavioral intentions and are moderated by different factors. A prospective member may, in principle, support the existence of SHI while objecting to the specific terms on offer. Understanding this distinction is important because policy responses differ: low WTJ calls for communication and trust-building strategies, while low WTP at a specific premium rate calls for premium redesign or benefit package enhancement.

Available estimates of WTJ for SHI in Ethiopia range from 47.5% to 74%, depending on the study population, region, and year of data collection. The higher values in this range come from teacher and other professional subgroups; willingness to pay among governmental-school teachers, for example, was about 62% in Gondar and as high as 89.5% in the Harar region [6, 7]. Regassa and colleagues [8], studying public sector workers in the Didu Woreda, South West Ethiopia, found that 47.5% expressed willingness to join SHI. Among those willing to join, 58.6% were further willing to pay the specified premium, meaning that effective WTP in the sample was barely above a quarter of the total workforce surveyed. These figures are not outliers: they are consistent with a pattern of majority non-uptake reproduced across multiple settings, cities, and professional groups in Ethiopia over more than a decade of research.

On the more optimistic end, Zarepour and colleagues [3], analyzing cross-sectional data from 2,749 formal sector employees across four major cities, found that 67% of respondents supported the introduction of SHI. This figure merits careful interpretation, however. Support for the existence of SHI in principle is

conceptually different from willingness to contribute 3% of salary. Among the same sample, only 24% were willing to pay the proposed 3% premium, with average WTP estimated at 1.6% of gross monthly income [3]. The gap between expressed support (67%) and willingness to pay at the proposed rate (24%) is perhaps the most important empirical finding in the SHI literature, because it exposes the premium affordability problem with precision. Ethiopian formal sector workers broadly want health insurance; they simply do not want to pay the price the 2010 design assumed they would accept.

The 2024 PLoS ONE systematic review and meta-analysis by Kaso and colleagues [9], registered at PROSPERO (CRD42023457003) and drawing on twenty studies (8,744 participants) published up to June 2022, produced a pooled WTP estimate for public civil servants of 49.62% (95% CI: 36.41-62.82%). The earlier Frontiers in Public Health meta-analysis by Bayked and colleagues [10], which reviewed 19 studies and pooled 18 of them (8,386 participants), produced a pooled WTP of 42.25% for the broader formal sector population. The divergence between these two pooled estimates reflects the heterogeneity of populations studied: WTP tends to be higher among health professionals and civil servants with better knowledge of the scheme, and lower among private sector workers and those in higher income quintiles who derive less expected benefit from a scheme limited to public facilities.

**Determinants of WTJ and WTP**

The literature identifies several categories of determinants. Sociodemographic and economic factors consistently predict WTP. Lower-income workers, those with more dependents, and female heads of household tend to express higher WTP, reflecting the greater expected marginal benefit from coverage for those who face higher healthcare cost burdens relative to income. Workers in the two highest income quintiles, who predominantly use private facilities, show the lowest support for a scheme they perceive as offering them nothing they do not already purchase independently [3]. This income-gradient finding has direct implications for scheme design: a benefit package that credibly includes private facility access is likely to shift the WTP distribution upward among the high-income cohorts whose premium contributions are most financially significant.

Knowledge and information about the scheme is a robust predictor across multiple studies. Workers who understand what the scheme covers, how premiums and benefits work, and what the claims process involves are systematically more likely to express willingness to join and pay. This finding suggests that low WTP partly reflects information asymmetry and that well-designed information campaigns could shift behavior without any change to the scheme's financial parameters.

Provider network composition emerges as the most structurally significant moderator of WTP. Outpatient care patterns in Ethiopia are dominated by private providers: Zarepour and colleagues [3] found that 55.9% of outpatient visits in their sample were to private facilities. Inpatient care, by contrast, was predominantly provided by public hospitals (62.5%). The proposed SHI scheme, as designed in 2010, was expected to initially contract primarily public facilities. This creates what Zarepour et al. [3] describe as a fear of double payment: mandatory premium contributions alongside continued out-of-pocket spending at private facilities. Until the EHIS credibly commits to including a network of private providers, a substantial portion of formal sector workers will rationally assess SHI as a net financial loss rather than a gain.

Prior health insurance experience, particularly CBHI membership, is positively associated with WTP for SHI. This finding, documented in several regional studies, points to the potential for leveraging CBHI's strong

enrollment and renewal rates (78% and 91% respectively in 2023) as a trust-building asset for SHI advocacy. The formal sector workers who live in communities where CBHI functions well have seen risk pooling in action; their resistance is not to insurance per se, but to the specific design of SHI.

### Quality Concerns as a WTP Depressant

Beyond premium affordability, perceived quality of care at contracted public facilities acts as a discrete and independent depressant of WTP. Multiple studies find that even formal sector workers who report the 3% premium as affordable still express unwillingness to pay, because they do not expect the scheme to improve their access to care of acceptable quality. This is not irrational. The national Service Availability and Readiness Assessment (SARA) 2018 found mean availability of basic amenities at only 39%, diagnostics at 40%, and standard precautions at 42% across Ethiopian health facilities [11]. A health insurance scheme that locks workers into contracting with this facility landscape, while prohibiting them from using private providers they currently prefer, offers a negative value proposition even at zero premium cost.

This quality feedback loop creates a structural policy dilemma: low quality reduces WTP, limiting premium revenue, which constrains the resources available to upgrade quality, which perpetuates low WTP. Breaking this cycle requires simultaneous investments in provider quality and in scheme design modifications, particularly private sector inclusion, that make SHI attractive to formal sector workers before quality improvements in the public sector are fully realized.

### Regional and Sectoral Heterogeneity

WTP and WTJ are not uniform across Ethiopia's regions or formal sector employee categories. Support for SHI has been found to be highest in regions where CBHI coverage is extensive and service quality has improved, and lowest in areas affected by conflict and governance disruption. Mebratie and colleagues [1] found support for a combined CBHI-SHI scheme (a construct distinct from SHI-specific willingness to pay) lowest in Tigray (63%) and Oromia (69%), and highest in SNNPR (88%), a distribution that correlates with regional variation in service quality and trust in federal institutions. These findings counsel against uniform national rollout of SHI without attention to regional variation in readiness and in the determinants of enrollment behavior.

## Institutional Preparedness of the Ethiopian Health Insurance Service

### Governance and Organizational Structure

The Ethiopian Health Insurance Agency was established through Council of Ministers Regulation No. 191/2010 and was later renamed the Ethiopian Health Insurance Service (EHIS) to reflect its expanded scope. EHIS operates as an autonomous federal organ with a mandate to implement both CBHI and SHI. It has established 24 branch offices across the country and is organizationally responsible for enrollment management, claims processing, provider contracting, and scheme oversight. The ILO, through its PROSPECTS programme, has recognized the importance of EHIS's institutional development and conducted a four-day training in July 2024 for EHIS officials and partner stakeholders on social health protection administration [12].

However, a candid assessment of EHIS's preparedness for SHI administration reveals substantial gaps. A WHO mission to Ethiopia conducted in September 2023, at the joint request of the Ministry of Health and EHIS, found that core health financing policy issues including the pooling architecture, SHI implementation status, and strategic purchasing remained unresolved [13]. The mission's work led to a joint plan of action for health financing and Health Technology Assessment development, signaling that the institutional

groundwork required for SHI had not yet been completed. This is a significant finding: more than thirteen years after the agency was established to implement SHI, the policy framework for how SHI will purchase services remains under development.

**Claims Management and Information Systems**

Claims management is perhaps the most technically demanding operational challenge in SHI administration. Processing claims from potentially thousands of contracted facilities, verifying clinical coding, detecting and deterring fraud, and ensuring timely payment to providers requires robust information technology infrastructure, trained staff, and tested protocols. The European Commission, through the m4health AG initiative commissioned by the Ethiopian Ministry of Finance, has been supporting EHIS in developing IT solutions for both CBHI and SHI. As the m4health project documentation notes, Ethiopia's prior CBHI software did not fully support critical processes such as enrollment, claims management, and payments, and a software prototype for SHI was being developed under this initiative [14]. This ongoing development work confirms that EHIS's ICT infrastructure for SHI is not yet operational.

The LSHTM/R4D financing brief on primary healthcare purchasing in Ethiopia [15] noted the existence of multiple purchasers in Ethiopia's health system, including the Ministry of Health, Regional Health Bureaus, EHIS, and donors, and the resulting risk of fragmentation, double budgeting, and misaligned provider incentives. For SHI, this fragmentation problem is particularly acute: EHIS would be a new, large purchaser entering a market already crowded with competing payment streams, and the absence of a clear strategic purchasing framework risks creating perverse incentives at the facility level. R4D and the Strategic Purchasing Africa Resource Centre (SPARC) were supporting EHIS on a provider payment mechanism assessment at the time of this review, but recommendations had not yet been finalized or implemented [16].

**Provider Contracting Capacity**

SHI's operation depends on a network of contracted providers willing and able to serve as scheme facilities, bill EHIS for services rendered, and maintain the clinical and administrative documentation required for claims verification. Ethiopia's experience with CBHI provider contracting has been instructive. As R4D [16] documents, challenges affecting CBHI implementation include the low readiness of health facilities, characterized by inadequate and unreliable infrastructure, power, water, functional equipment, funds, and trained staff, which have placed CBHI implementation in ongoing jeopardy. These are the same facilities that would constitute the initial SHI provider network. Without significant facility-level investment and quality upgrading, the SHI provider network will not be credible to potential members.

Private sector contracting represents the critical variable that current institutional arrangements do not adequately address. The existing SHI design did not clearly specify the terms under which private providers would be contracted. Given that over half of outpatient care in urban Ethiopia is delivered by the private sector, an SHI without meaningful private sector inclusion is structurally incomplete. Developing and operationalizing a private provider contracting framework requires regulatory work, quality standards development, and negotiation capacity that EHIS has not yet demonstrated at scale.

**Human Resources and Organizational Capacity**

EHIS's organizational capacity for SHI is stretched. The agency has primarily built its operational expertise around CBHI

implementation, where enrollment, premium collection, and provider payments operate through relatively decentralized and community-mediated systems. SHI administration, involving compulsory payroll deductions, employer reporting obligations, dependent registration, and complex claims processing, requires a fundamentally different set of competencies. The ILO training in 2024 [12] was partly intended to address this gap, but four-day training events, however well designed, cannot substitute for the sustained organizational development, systems investment, and staff specialization required for a large-scale mandatory insurance scheme.

## Fiscal Space for Social Health Insurance

### The Fiscal Space Concept and Ethiopia's Situation

Fiscal space for health is defined as the capacity of a government to increase health financing without compromising macroeconomic stability or the sustainability of public finances [17]. For SHI, fiscal space matters in two ways: the government must co-finance SHI for public sector employees (both as employer contributor and as budget guarantor of the scheme's solvency), and it must subsidize enrollment for low-income formal sector workers and potentially cross-subsidize CBHI through eventual risk pool integration. The availability of fiscal space thus shapes both the initial premium structure and the long-term financial sustainability of the scheme.

Ethiopia's current fiscal position is simultaneously constrained and undergoing structural transformation. The tax-to-GDP ratio of 6.8% is the most fundamental constraint: at roughly half the Sub-Saharan African average and less than half the threshold considered necessary for financing the Sustainable Development Goals (15% of GDP), it leaves very limited margin for additional discretionary public spending [18]. The country defaulted on a USD 33 million Eurobond coupon payment in December 2023 [19] and is assessed by the IMF and World Bank as being at high risk of debt distress. The fiscal deficit narrowed to 2.0% of GDP in 2023/24, an improvement from 2.6% the previous year, but the path was achieved partly through reduced spending on priority sectors including health [20].

Against this challenging backdrop, there are credible signals of a structural shift in health financing ambition. The health sector budget grew from ETB 100.2 billion in 2023/24 to ETB 143.4 billion in 2024/25, a nominal increase of 43% [21]. The National Health Compact [4] projects total health expenditure growing from USD 4.8 billion in 2024 to USD 8.3 billion by 2030, with the government's share of total health financing targeted to double from 27% to 53%. This ambition is underpinned by a medium-term revenue strategy, plans for health tax revenues from tobacco, alcohol, and high-sugar beverages, and efficiency gains from digitalization targeting 83% of district-level primary healthcare service delivery.

### Government Co-financing Requirements for SHI

For SHI to launch, the government faces at least three categories of co-financing obligations. First, as an employer, the government must contribute the employer-side premium (equivalent to 3% of gross salary per employee) for all civil servants enrolled in SHI. Given the estimated size of the civil service, this represents a substantial recurrent budgetary commitment. Second, the government may need to provide start-up capitalization for the SHI fund and reinsurance arrangements to guard against adverse selection risk during the early, low-enrollment phase. Third, subsidies will be required for lower-income formal sector workers for whom even the member-side 3% contribution is unaffordable, as well as for pensioners whose fixed incomes may not sustain premium contributions over time.

A fiscal space analysis using the World Bank's decomposition framework (Government

health expenditure per capita equals health share of government budget multiplied by government budget as share of GDP multiplied by GDP per capita) reveals the levers available. With GDP per capita relatively low and growing from a small base, with government expenditure as a share of GDP at an estimated 18%, and health's share of government spending at an estimated 9% (author approximations based on the national health budget briefs [20, 21]), the scope for immediate large-scale increases in absolute health spending is limited in real terms. However, the decomposition also points to the potential of incremental improvements: a one percentage point increase in the health share of the government budget, combined with projected GDP growth of 7%, would yield meaningful additional resources that could be ring-fenced for SHI co-financing and facility quality upgrading.

### SHI Premium Revenue as a Domestic Resource Mobilization Instrument

An important but sometimes overlooked dimension of fiscal space analysis is that SHI is itself a domestic resource mobilization instrument. When functioning at scale, the SHI scheme generates a revenue stream from employer and employee contributions that is wholly domestic, countercyclical to donor financing, and self-reinforcing as enrollment grows. For Ethiopia, whose health system is approximately 33-36% dependent on external development assistance [22], the institutionalization of SHI would represent a significant diversification of the health financing base. A scheme covering Ethiopia's estimated 4 to 4.5 million formal sector employees at even a 2% employee contribution rate would, on an illustrative author calculation assuming average covered earnings in the region of USD 150 to 200 per month, generate on the order of several hundred million US dollars annually, rivaling the contribution of some major bilateral donors.

This framing reframes fiscal space from a question of whether the government can afford SHI to a question of whether Ethiopia can afford not to have SHI. The transition from external financing dependency to domestically funded health coverage is exactly the shift that the National Health Compact targets. SHI is a primary instrument for achieving that transition. The challenge is managing the fiscal commitments required during the ramp-up phase, when enrollment may be low and adverse selection risks are highest, before the scheme reaches the enrollment threshold at which premium revenues cover running costs.

### External Financing for the Transition Period

International experience from Ghana, Rwanda, and Kenya suggests that external donor financing of the SHI transition period, covering start-up costs, actuarial modeling, IT infrastructure, and initial deficit financing, is both common and effective. Rwanda's community health insurance scheme, Mutuelle de Sante, received sustained World Bank and other donor support during its scale-up phase before becoming financially self-sustaining. The National Health Compact process and the associated World Bank engagement in Ethiopia create a policy window for similar transition financing, provided the government presents a credible actuarial and implementation plan.

## Health Service Availability and Readiness

### The Service Supply Constraint on Insurance Attractiveness

Health insurance is only as valuable as the services it enables access to. If the facilities contracted under SHI cannot reliably deliver the services in the benefit package, the scheme becomes, in effect, a tax rather than an insurance product. This supply-side constraint is not peripheral to the SHI feasibility question; it is central to it. Formal sector workers in Ethiopia's urban centers have demonstrated,

through their healthcare seeking behavior, that they do not rely primarily on public facilities for outpatient care [3]. Any SHI scheme that does not address this quality differential, or that does not include private providers with adequate quality, is asking workers to pay for inferior access.

**Physical Infrastructure and Facility Network**

Ethiopia has made remarkable quantitative progress in health infrastructure expansion. Primary healthcare service coverage, measured as access to a facility within a two-hour walk, increased from 51% in 2000 to greater than 90% by 2019 [1]. As of 2022, there were 227 primary hospitals, 3,587 health centres, and 17,534 health posts operating within the primary healthcare arrangement [23].

However, the quantitative expansion of facilities has not been matched by qualitative readiness to deliver the services that an SHI benefit package would require. The national SARA 2018 survey, which underpins the HSTP II baseline, found mean availability of basic amenities across Ethiopian health facilities at only 39%, basic equipment at 60%, standard precautions at 42%, and diagnostics at 40% [11]. A 2024 assessment of primary healthcare capacity, conducted from April to June 2024 across all regional states, concluded that the capacity of Ethiopia's primary healthcare system was limited in delivering quality health services and that overall performance remained insufficient to progress toward UHC [23]. These assessments, taken together, suggest that the public facility network is not ready to serve as a credible SHI provider network without substantial quality investment.

**Essential Medicines and Diagnostics**

Availability of essential medicines and diagnostics is among the most frequently cited quality deficits in Ethiopian public facilities and among the most frequently cited barriers to WTP for SHI. Workers who encounter drug stockouts or unavailable laboratory services at public facilities will find little value in an insurance card that nominally entitles them to those services. The 40% mean availability of diagnostics documented in the SARA 2018 survey [11] implies that in the average public facility, three out of five required diagnostic tests are not reliably available. For SHI to be credible, contracted facilities must maintain formulary adherence and diagnostic availability at a level that members can observe and verify.

The EHIS documented over 530 benefit package items for CBHI in its 2017/18 report [24], a figure that predates subsequent package revisions, reflecting the scope of what the benefit package aspires to deliver. Ensuring that contracted facilities consistently have the medicines and equipment to deliver even a core subset of this benefit package requires a supply chain investment that goes beyond what the EHIS alone can mandate. It requires coordination between EHIS, the Federal Ministry of Health, the Ethiopian Pharmaceuticals Supply Service, and the Ethiopian Food and Drug Authority.

**Non-Communicable Diseases and the Evolving Burden**

Ethiopia is in a health transition. While communicable diseases, maternal conditions, and malnutrition remain significant contributors to the burden of disease, non-communicable diseases (NCDs) are growing in importance, particularly in urban formal sector populations. The Ethiopia Service Provision Assessment (ESPA) 2021/22 found that 84% of health facilities offered at least one NCD service, but only 26% offered mental health services [23]. Cardiovascular disease, diabetes, and chronic respiratory conditions, the leading NCDs in urban Ethiopia, require reliable diagnostic capacity, sustained medicine availability, and trained outpatient management protocols, precisely the capabilities in shortest supply in the public sector.

This NCD transition matters for SHI benefit package design. The formal sector workforce skews urban, middle-aged, and sedentary, making it a population with above-average NCD risk. A benefit package that does not cover NCD management will be seen as inadequate by the very demographic it targets. At the same time, including NCD management without corresponding supply-side investment in diagnostic and pharmacological capacity would result in nominal coverage without effective access, damaging trust in the scheme.

### Human Resources for Health

Ethiopia's physician density remains critically low, estimated at 0.1 physicians per 1,000 population by the World Bank [21]. Health center staffing is predominantly at the level of nurses, health officers, and midwives, with limited specialist coverage below the hospital tier. While task-shifting has been used strategically to expand primary care, the staffing gaps at health centers and primary hospitals mean that contracted facilities under SHI may face workload surges, particularly in outpatient departments, without the human resource capacity to sustain quality. Provider payment mechanisms must therefore be designed with workforce sustainability in mind, including incentives for health worker retention and appropriate remuneration, rather than purely on cost-containment principles.

## Synthesis: The Four Domains as an Integrated Policy System

### Interdependencies and Feedback Loops

A central contribution of this review is to show that the four domains are not independent barriers to SHI launch but are components of a single, interconnected policy system. Low WTP is not simply a financing problem solvable by reducing the premium rate; it is substantially driven by rational assessments of service quality and provider network scope, which are supply-side problems. Low institutional readiness is not simply an administrative problem; it is partly a consequence of fiscal constraints that limit EHIS's ability to invest in IT infrastructure and human capacity. Fiscal space constraints are not simply a macroeconomic problem; they are partly addressable through the premium revenue that SHI itself would generate once enrollment reaches scale. And service quality deficits are not simply a supply-side problem; they are partly addressable through the strategic purchasing leverage that a well-capitalized SHI fund would possess.

This systems view has important policy implications. Interventions targeted at only one domain in isolation are unlikely to succeed. A premium rate reduction without private sector inclusion will not substantially shift WTP among higher-income workers. Institutional capacity building without a credible provider quality improvement agenda will not build member trust. Fiscal space analysis without SHI revenue projections will underestimate the scheme's self-financing potential. And facility quality upgrading without a concomitant enrollment drive that generates demand and revenue will not be sustained. Successful SHI launch in Ethiopia requires coordinated, sequenced action across all four domains.

### Comparative Lessons from the Region

Rwanda's experience with Mutuelle de Sante demonstrates that community and social health insurance can achieve high enrollment and financial protection in low-income settings, provided certain design features are in place: income-tiered premium contributions, government subsidization of the poorest quintile, sustained investment in facility quality, and credible claims management. Rwanda now has among the highest health insurance enrollment rates in Africa, with the published literature associating the scheme with reductions in out-of-pocket expenditure. Ghana's National Health Insurance Scheme (NHIS), despite well-documented financial sustainability challenges, has shown that formal

sector integration into a broader national health insurance pool can significantly expand coverage, provided actuarial discipline is maintained and exemption categories are clearly defined. Kenya's National Hospital Insurance Fund, replaced from October 2024 by the Social Health Insurance Fund (SHIF) under the newly established Social Health Authority (Social Health Insurance Act, 2023), provides a cautionary example [25] of what happens when claims management capacity, provider payment timeliness, and benefit package scope are not adequately resourced at launch.

From these regional comparisons, three consistent lessons emerge. First, income-tiered or sliding-scale premium structures consistently produce higher enrollment and greater equity than flat-rate schemes. Ethiopia's January 2024 adoption of a sliding-scale contribution model for CBHI, approved by the national CBHI council, represents a promising innovation that should be analyzed for applicability to SHI. Second, private sector inclusion in the provider network is associated with higher uptake, particularly among upper-income formal sector workers. Third, a trusted and transparent administrative agency is a necessary precondition for enrollment: schemes perceived as poorly managed or financially unsound consistently experience enrollment resistance regardless of premium level.

### The CBHI-SHI Integration Opportunity

CBHI's strong enrollment and renewal performance provides an institutional asset that Ethiopian policymakers should leverage more deliberately for SHI. By 2023, CBHI's enrollment rate was 78% and renewal was 91% [1]. The scheme reached 12.1 million households across 1,011 districts, covering more than half of Ethiopia's population. Formal sector workers who live in communities with functioning CBHI, who have seen insurance work, and who understand risk pooling through direct household experience, are demonstrably more receptive to SHI. A communication strategy for SHI that builds on the CBHI narrative, rather than treating the two schemes as entirely separate policy objects, could leverage this familiarity to reduce the information gap that partly accounts for low WTP.

In the longer term, the convergence of SHI and CBHI into a single national health financing pool, as envisioned by the EHIS ten-year strategic plan [26], would represent the most significant structural advance toward UHC. A unified pool would allow cross-subsidization from higher-income formal sector members to lower-income CBHI members, improving the financial sustainability of both schemes and deepening Ethiopia's social solidarity in health financing. The design of that convergence, however, requires the four domains analyzed in this review to be adequately addressed within each scheme before integration is attempted.

## Policy Implications and Advocacy Recommendations

### Redesign the Premium Structure Based on Updated Evidence

The most immediate implication of the WTP evidence is that the 3% flat-rate premium, calibrated to 2010 salary data, is not viable as currently designed. The average WTP of 1.6% of gross salary documented by Zarepour and colleagues [3] suggests that an initial contribution rate of 1.5% to 2%, with a pathway to 3% as scheme performance improves and member trust builds, is more consistent with the revealed preferences of the target population. This inference should be treated with caution, as the underlying estimates derive from contingent-valuation surveys of stated willingness, which may overstate actual contribution behavior; the proposed rate therefore warrants validation against enrolment data once the scheme is piloted. This rate adjustment should be accompanied by a comprehensive actuarial reassessment using current salary distributions and cost-of-care

data, to determine the benefit package scope that is financeable at lower contribution rates with government co-financing bridging the gap.

**Mandate Private Provider Inclusion from Day One**

No single design change is more likely to shift the WTP distribution among formal sector workers than credible private provider inclusion in the SHI network. The fear of double payment, which depresses WTP even among workers who find the 3% premium affordable [3], is only resolved when the SHI card provides access to the facilities workers actually use. The government and EHIS should move urgently to develop a private provider contracting framework, with minimum quality standards, a tiered fee schedule, and anti-fraud safeguards, that can enable a meaningful cohort of accredited private facilities to participate in SHI from its inception.

**Invest in Provider Quality as a Prerequisite, Not a Parallel Track**

The supply-side evidence reviewed in Section 6 makes clear that facility quality upgrading is not an optional complementary investment to SHI: it is a prerequisite for SHI to deliver value. The low availability of basic amenities (39%), diagnostics (40%), and essential medicines documented across Ethiopian public facilities [11] must be addressed at contracted facilities before, or at minimum in parallel with, SHI enrollment. A phased launch strategy, starting with facilities that already meet defined quality thresholds and expanding as additional facilities achieve those standards, would be more credible than a blanket rollout across an unprepared provider network.

**Prioritize EHIS Institutional Capacity Building as a Critical Path Item**

SHI cannot be launched without a functioning claims management system, a trained cadre of medical auditors, an operationalized provider payment mechanism, and an ICT infrastructure capable of processing enrollment, claims, and payments at scale. The EC-funded m4health digitalization initiative [14] is laying groundwork, and the WHO [13], ILO [12], and USAID HFIP [27] are providing technical assistance. But these efforts need to be explicitly framed as critical path items with non-negotiable completion milestones that condition the launch date. EHIS should publish and regularly update an institutional readiness scorecard against which donors, the government, and civil society can track progress.

**Use the National Health Compact Framework to Mobilize SHI Co-Financing**

The National Health Compact, endorsed in 2025 [4], is the most significant high-level policy commitment to transforming Ethiopian health financing since the original SHI proclamation. Its target of doubling the government's share of health financing from 27% to 53% by 2030, and its projection of total health expenditure reaching USD 8.3 billion, provide the fiscal ambition framework within which SHI co-financing commitments should be explicitly nested. The government should table a SHI co-financing budget line, representing the employer contribution for civil servants and a subsidy allocation for vulnerable workers, in the Medium-Term Expenditure Framework, making SHI financing a committed and trackable item in the federal budget.

**Conduct a Comprehensive Feasibility Reassessment Before Launch**

The synthesis of evidence across the four domains reviewed in this paper points consistently to one conclusion: the evidence base generated in 2010/11 is no longer adequate to support a sound launch decision. Macroeconomic conditions, the labor market, the facility landscape, institutional capacity, and the political economy have all changed substantially. A comprehensive feasibility

reassessment, covering updated actuarial projections, WTP at revised premium scenarios, provider readiness, EHIS institutional capacity, and fiscal space, is the most risk-reducing investment the government and its development partners can make before a launch decision. This call is consistent with recommendations from the WHO September 2023 mission to Ethiopia [13] and with the direction of travel in the National Health Compact [4].

## Limitations of This Review

This review has several limitations that should be acknowledged. First, as a narrative review, it does not apply systematic eligibility criteria to the selection and weighting of evidence, potentially introducing selection bias. Second, the WTP literature is dominated by contingent valuation methods, which can produce aspirational rather than behaviorally predictive estimates. Stated WTP in survey contexts may differ from revealed WTP in actual enrollment decisions. Third, the service readiness evidence draws heavily on the SARA 2018 survey and the ESPA 2021/22, which predate the most recent period of post-conflict reconstruction and may not fully capture current facility status in previously conflict-affected regions. Fourth, fiscal space projections are inherently uncertain in a rapidly changing macroeconomic environment, and the National Health Compact targets, while ambitious, are aspirational rather than contractually committed. These limitations do not invalidate the review's conclusions, but they reinforce the argument for updated primary research before SHI launch decisions are finalized.

## Conclusion

Ethiopia's Social Health Insurance program has waited too long to be designed on the basis of old evidence. The formal sector workforce, the macroeconomic environment, the healthcare delivery landscape, and the institutional capacity of the EHIS are all materially different in 2025 from what they were in 2010. This review has shown that the four domains critical to SHI feasibility, namely willingness to join and pay, institutional preparedness, fiscal space, and service availability, are individually constrained and mutually reinforcing in ways that require policy responses calibrated to their interactions.

WTP at the proposed 3% premium is well below the threshold needed for financial sustainability, and it will remain so until the provider network credibly includes private facilities and until public facility quality is demonstrably improved. EHIS's institutional capacity, while growing, has critical gaps in claims management, strategic purchasing, and provider contracting that must be resolved before the scheme can operate. Fiscal space is tight but not prohibitive, and SHI's own premium revenue has the potential to become a major domestic financing instrument if the scheme is designed to reach and sustain high enrollment. And service readiness, particularly for outpatient diagnostics and essential medicines, is the most fundamental constraint of all, because a health insurance scheme that cannot reliably deliver the services it promises will erode trust faster than any communication campaign can rebuild it.

The policy window for getting SHI right in Ethiopia is open. The National Health Compact, the renewed government commitment to launch, and the sustained engagement of major development partners all point in the same direction. What is needed now is the disciplined commitment to update the evidence base, redesign the scheme parameters that the evidence identifies as inadequate, and build the institutional machinery that a credible SHI requires. The cost of doing this work is a fraction of the cost of a failed launch. The obligation to the millions of Ethiopian workers and families who stand to benefit from a functioning scheme is to get it right.

## Author Contributions

Wudalew Meselu Tesfaye conceptualized the study, designed the review framework, conducted the literature search and screening, performed the narrative synthesis, and drafted the full manuscript. The author read and approved the final version submitted for publication.

## Conflict of Interest

The author declares no conflict of interest, financial or otherwise, in relation to the research, authorship, and publication of this article. The views expressed are those of the author alone and do not represent the official position of any affiliated organization.

## Ethical Approval

This article is a secondary narrative review of previously published literature and publicly available policy documents. No primary data collection involving human participants was conducted. Accordingly, formal ethical approval was not required. All cited sources are appropriately acknowledged in accordance with standard academic practice.

## Data Availability

This review is based entirely on publicly available published literature and open-access policy documents. No primary datasets were generated or analyzed. All sources are cited in the reference list and can be accessed through the URLs and DOIs provided.

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# Knowledge-Practice Gaps in Antimicrobial Prescribing among Nigerian Healthcare Providers: A Systematic Review and Meta-Analysis

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***Abstract*** *Antimicrobial resistance (AMR) remains a major public health challenge globally, with low- and middle-income countries such as Nigeria carrying a substantial burden because of irrational antibiotic use, weak antimicrobial stewardship (AMS) systems, and limited diagnostic capacity. This systematic review and meta-analysis synthesized evidence on AMR knowledge, AMS awareness, and antibiotic prescribing practices among healthcare workers in Nigeria. A comprehensive search of PubMed, Scopus, and Web of Science identified 136 records, of which 17 studies met the eligibility criteria for qualitative synthesis and 15 were included in quantitative meta-analysis. Quantitative synthesis was conducted using a random-effects model. The pooled proportion of healthcare workers demonstrating good AMR knowledge was 64.8% (95% CI: 58.1%–71.2%), while AMS awareness was lower at 49.3% (95% CI: 41.2%–57.5%). Poor or inappropriate antibiotic prescribing practices remained common, with a pooled prevalence of 61.7% (95% CI: 53.4%–69.6%), whereas empirical antibiotic prescribing reached 72.9% (95% CI: 65.1%–79.8%). Recent AMS training exposure was also limited at 38.6% (95% CI: 30.4%–47.5%). Narrative synthesis revealed persistent gaps in stewardship implementation, diagnostic limitations, weak institutional support, pharmaceutical influence, and inadequate continuous professional education across healthcare settings. The findings demonstrate that moderate awareness of AMR among Nigerian healthcare workers has not translated into rational antimicrobial prescribing practices. Strengthening institutional AMS programs, improving diagnostic infrastructure, expanding stewardship training, and implementing behavior-focused interventions are urgently needed to reduce irrational antimicrobial use and curb the growing burden of AMR in Nigeria.*

***Keywords*** *Antibiotic Prescribing, Antimicrobial Resistance, Antimicrobial Stewardship, Healthcare Workers, Nigeria, Systematic Review.*

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## Introduction

Antimicrobial resistance (AMR) is one of the most significant public health threats facing healthcare systems worldwide because it reduces the effectiveness of antimicrobial agents used to treat infectious diseases [1]. The increasing resistance of microorganisms to commonly used antibiotics has led to higher morbidity, mortality, prolonged hospital stays, and rising healthcare costs. The World Health Organization (WHO) identifies AMR as a major global health concern because resistant infections threaten advances in modern medicine, including surgery, cancer treatment, maternal healthcare, and the management of infectious diseases [2]. Recent evidence indicates that AMR contributes to millions of deaths annually, with low- and middle-income countries (LMICs) carrying a substantial share of the burden due to high infectious disease prevalence and limited healthcare resources [3]. According to Ofori-Asenso & Agyeman [4], a major driver of AMR is the inappropriate use of antibiotics, including unnecessary prescribing, empirical treatment without laboratory confirmation, prolonged use, and misuse of broad-spectrum agents. Consequently, global efforts to combat AMR emphasize antimicrobial stewardship (AMS), rational prescribing, infection prevention, surveillance, and awareness creation among healthcare professionals [5].

The burden of AMR is particularly severe in LMICs where healthcare systems often face weak stewardship structures, inadequate laboratory capacity, poor infection prevention measures, and weak regulation of antibiotic distribution [5]. Easy access to antibiotics without prescription remains common in many settings, encouraging self-medication and inappropriate use. Chukwu et al. [6] state that limited diagnostic facilities also contribute to irrational prescribing because clinicians frequently depend on empirical treatment when microbiological investigations are unavailable or unaffordable. Nigeria faces similar challenges, with studies reporting widespread misuse of antibiotics across healthcare settings and increasing dependence on broad-spectrum antimicrobial agents [6-8]. Evidence from different regions of the country has documented frequent empirical prescribing, low awareness of stewardship principles, inadequate adherence to treatment guidelines, and insufficient antimicrobial surveillance systems [7, 8]. In response to these challenges, Nigeria developed the National Action Plan on Antimicrobial Resistance (NAPAR) to strengthen surveillance, stewardship implementation, infection prevention, and multisectoral collaboration [9]. However, gaps in funding, infrastructure, and institutional support continue to limit effective implementation of stewardship activities across many healthcare facilities.

Healthcare workers play a central role in controlling AMR because their prescribing decisions, dispensing practices, and infection control activities directly influence antibiotic use and stewardship outcomes [10]. Physicians, pharmacists, nurses, laboratory scientists, and community health extension workers (CHEWs) are critical stakeholders in promoting the rational use of antimicrobials. Babatola et al. [8] note that their knowledge and understanding of AMR influence antibiotic selection, treatment duration, patient counseling, and adherence to stewardship guidelines. Studies conducted in Nigeria have shown that irrational prescribing practices remain common among healthcare professionals. Umeokonkwo et al. [11] highlight that antibiotics are frequently prescribed for viral infections, while Ogoina et al. [12] state that empirical prescribing often occurs without antimicrobial susceptibility testing due to diagnostic limitations, fear of treatment failure, patient expectations, and concerns about drug availability. Community pharmacists have also been linked to inappropriate antibiotic dispensing practices, including dispensing antibiotics without valid

prescriptions [13]. Furthermore, healthcare workers in primary healthcare facilities continue to demonstrate important gaps in stewardship training and implementation. Although many healthcare professionals demonstrate moderate to good knowledge of AMR and positive attitudes toward stewardship principles, evidence consistently shows that this awareness does not translate into appropriate prescribing behavior [5, 9]. Empirical prescribing, poor guideline adherence, limited stewardship implementation, and continued use of unnecessary antibiotics remain widespread [3]. This persistent gap between knowledge and practice represents a major challenge to antimicrobial stewardship efforts in Nigeria and serves as a central focus of this review.

Although several studies have examined AMR and AMS among healthcare professionals in Nigeria, the available evidence remains fragmented across different professional groups, healthcare settings, and regions of the country. Existing studies vary considerably in their assessment of knowledge, attitudes, prescribing behavior, and stewardship practices, making it difficult to draw comprehensive conclusions regarding the current state of antimicrobial stewardship among Nigerian healthcare workers. While broader reviews have examined AMR awareness and stewardship practices in LMICs and sub-Saharan Africa [2, 3], there remains no comprehensive synthesis focused specifically on Nigerian healthcare workers. In addition, no previous review has integrated evidence on healthcare workers' knowledge, attitudes, prescribing practices, and barriers to stewardship implementation within the Nigerian context. Therefore, this systematic review and meta-analysis aims to synthesize available evidence on AMR and AMS among healthcare workers in Nigeria, identify major determinants of inappropriate antimicrobial use, examine barriers to stewardship implementation, and provide evidence to support policy development, professional training, and future interventions aimed at strengthening antimicrobial stewardship in the country.

## Materials and Methods

This study employed a systematic review with mixed-method synthesis to evaluate the knowledge, attitudes, practices, and antimicrobial stewardship (AMS) experiences of healthcare workers in Nigeria regarding antimicrobial resistance (AMR). The review integrated qualitative thematic synthesis with quantitative meta-analysis of proportions where outcome measures were sufficiently comparable across studies, similarly employed by [14]. Quantitative synthesis focused on pooled estimates of healthcare workers with good AMR knowledge, AMS awareness, empirical antibiotic prescribing, and poor prescribing practices. Narrative synthesis explored institutional, behavioral, and structural barriers influencing antimicrobial stewardship implementation across Nigerian healthcare settings. The conduct and reporting of the review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guideline to ensure methodological transparency and reproducibility [15].

### Eligibility Criteria

The methodology and reporting structure for this review followed the PRISMA 2020 statement for systematic reviews and meta-analyses [15]. Although prospective registration in the International Prospective Register of Systematic Reviews (PROSPERO) is recommended to strengthen transparency and reduce duplication, the protocol for this review was not registered. Nevertheless, the objectives, search strategy, eligibility criteria, quality appraisal tools, and synthesis methods were predefined before study selection commenced.

Studies were eligible for inclusion if they were conducted in Nigeria and examined antimicrobial resistance, antimicrobial stewardship, antibiotic prescribing behavior, or related knowledge, attitudes, and practices among healthcare workers. Eligible participants included physicians, pharmacists, nurses, dentists, medical laboratory scientists, community health extension workers (CHEWs), and other healthcare professionals involved in antibiotic prescribing, dispensing, or administration. Quantitative cross-sectional studies, mixed-method studies, and qualitative studies published in English between 2019 and 2026 were included because this period reflects increasing stewardship awareness and implementation efforts following Nigeria's National Action Plan on AMR [9].

Studies involving the general public, undergraduate students, editorials, reviews, conference abstracts, and studies without relevant stewardship or prescribing outcomes were excluded. Veterinary-only studies were excluded also from quantitative synthesis because antimicrobial use patterns in veterinary settings differ substantially from human healthcare systems; however, studies with broader One Health relevance informed contextual interpretation during narrative synthesis. Full eligibility assessment focused specifically on outcomes related to AMR knowledge, stewardship awareness, prescribing behavior, empirical antibiotic use, stewardship barriers, and institutional support systems.

## Search Strategy

A systematic literature search was conducted across PubMed, Scopus, and Web of Science because these databases index major biomedical, pharmaceutical, infectious disease, and healthcare systems research relevant to antimicrobial stewardship and AMR [14]. Additional manual searches of reference lists from eligible studies were conducted to identify potentially relevant articles missed during electronic searching. The final search was completed in May 2026. The search strategy combined Medical Subject Headings (MeSH) terms with free-text keywords using Boolean operators "AND" and "OR." Search terms included "antimicrobial resistance," "antibiotic resistance," "antimicrobial stewardship," "knowledge attitude practice," "healthcare workers," "prescribers," "antibiotic prescribing," "pharmacists," "physicians," "nurses," and "Nigeria." An example search syntax used in PubMed was: ("antimicrobial resistance" OR "antibiotic resistance") AND ("antimicrobial stewardship" OR "antibiotic stewardship") AND ("knowledge attitude practice" OR "prescribing behavior") AND ("healthcare workers" OR physicians OR pharmacists OR nurses) AND Nigeria. Search filters were applied where appropriate to limit results to human studies published in English.

## Study Selection and Data Extraction

The study selection process followed the PRISMA framework [15] as shown in Figure 1. A total of 136 records were identified across PubMed, Scopus, and Web of Science. After duplicate removal, 76 records remained for title and abstract screening. At this stage, 45 studies were excluded because they focused on non-healthcare populations, undergraduate students, veterinary-only populations, or lacked outcomes relevant to AMR and AMS among healthcare workers. Consequently, 31 full-text articles were assessed for eligibility. Following full-text screening, 17 studies satisfied the inclusion criteria and were included in the qualitative synthesis, while 15 studies with sufficiently comparable quantitative outcomes were included in the meta-analysis.

Data extraction was conducted using a structured template designed specifically for this review. Extracted variables included author names, publication year, study location or geopolitical zone, study design, healthcare

setting, sample size, participant population, and outcomes related to antimicrobial resistance and stewardship. Additional data included AMR knowledge scores, stewardship awareness levels, prescribing practices, empirical antibiotic use, predictors of irrational prescribing, institutional barriers, and major study findings. Extraction procedures were cross-checked carefully to minimize data entry errors and improve consistency across included studies.

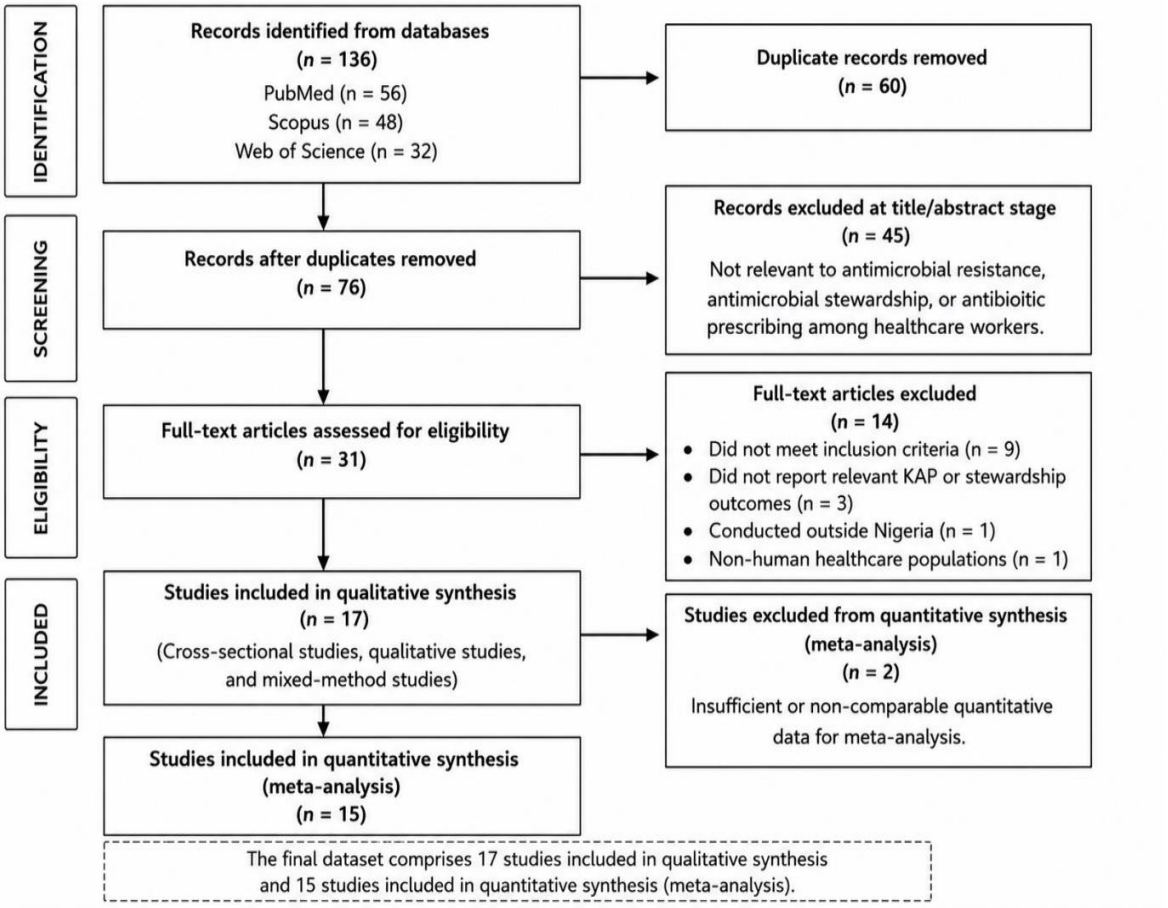


**Figure 1.** Study's PRISMA Flowchart

## Quality Assessment

Methodological quality appraisal was conducted to evaluate the validity and risk of bias of included studies. Quantitative cross-sectional studies were assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies [16]. This tool evaluates sampling methods, sample representativeness, exposure measurement reliability, confounding control, statistical analysis appropriateness, and outcome assessment consistency. Qualitative studies were appraised using the Critical Appraisal Skills Programme (CASP) Qualitative Checklist [17], which examines research design appropriateness, recruitment strategy, reflexivity, ethical considerations, data collection rigor, and credibility of findings.

Each study received a quality classification of low, moderate, or high risk of bias based on appraisal outcomes. Studies with methodological weaknesses were retained where they contributed important contextual evidence regarding stewardship barriers, prescribing culture, or institutional limitations. Quality appraisal findings informed interpretation of pooled prevalence estimates and thematic conclusions.

## Data Analysis

Quantitative synthesis was conducted for outcomes reported consistently across multiple studies. The primary pooled outcomes included the proportion of healthcare workers with good antimicrobial resistance (AMR) knowledge, awareness of antimicrobial stewardship (AMS), poor or irrational prescribing practices, empirical antibiotic prescribing, and exposure to recent AMS-related training. Since substantial methodological and clinical heterogeneity was anticipated across studies due to differences in healthcare settings, professional cadres, sample sizes, outcome definitions, and scoring systems, pooled prevalence estimates were calculated using a random-effects meta-analysis model based on the DerSimonian-Laird method [18]. This approach assumes that the true effect size varies across studies and therefore incorporates both within-study and between-study variance into the pooled estimate.

For each outcome, pooled prevalence estimates were computed using inverse-variance weighting as in (1). The pooled proportion ($P$) was estimated using the formula:

$$P = \frac{\sum w_i p_i}{\sum w_i} \qquad (1)$$

where $p_i$ represents the prevalence estimate reported in each study and $w_i$ denotes the inverse variance weight assigned to the study. The variance for each study proportion was calculated from the standard error of the proportion as in (2):

$$SE = \sqrt{\frac{p(1-p)}{n}} \qquad (2)$$

where $p$ represents the study prevalence and $n$ represents the study sample size. Pooled estimates were reported with corresponding 95% confidence intervals (95% CI).

Statistical heterogeneity across studies was assessed using Cochran's Q statistic, degrees of freedom (df), tau-squared $(\tau^2)$, and the $I^2$ statistic [19]. The Q statistic assessed whether observed differences across studies exceeded what would be expected from chance alone, while $\tau^2$ estimated the between-study variance in the random-effects model. The $I^2$ statistic quantified the percentage of total variability attributable to true heterogeneity rather than sampling error as in (3) and was calculated using:

$$I^2 = \frac{Q-df}{Q} \times 100\% \qquad (3)$$

where $Q$ represents Cochran's heterogeneity statistic and $df$ denotes degrees of freedom. Heterogeneity was interpreted using conventional thresholds: low (<25%), moderate (25%–49%), substantial (50%–74%), and considerable (≥75%). Statistical significance for heterogeneity was assessed at $p<0.05$.

Sensitivity analysis was performed through visual inspection of pooled estimates and heterogeneity patterns across studies to determine whether any single study exerted disproportionate influence on the pooled effect sizes. Forest plots were generated to visually present pooled prevalence estimates and study-specific confidence intervals for each quantitative outcome. Forest plots were generated using Matplotlib within a Python analytical environment.

Narrative and thematic synthesis complemented the quantitative analysis because several included studies reported contextual, behavioral, and qualitative findings unsuitable for statistical pooling. Thematic synthesis enabled integration of evidence across heterogeneous healthcare settings and professional groups [14]. Major themes identified across the included studies included the disconnect between AMR awareness and prescribing behavior, absence or poor implementation of AMS programs, diagnostic and laboratory limitations, cost-driven prescribing decisions, pharmaceutical industry influence, inadequate continuous professional education, weak institutional support systems,

and the persistence of empirical prescribing culture across primary, secondary, and tertiary healthcare facilities in Nigeria. These themes provided deeper insight into the structural and behavioral drivers of irrational antimicrobial use among healthcare workers.

## Results

### Characteristics of Included Studies

Seventeen studies met the eligibility criteria and were included in the qualitative synthesis, while 15 studies with sufficiently comparable quantitative outcomes were included in the meta-analysis. Most studies employed cross-sectional survey designs and were conducted among physicians, pharmacists, nurses, community health extension workers (CHEWs), and multidisciplinary healthcare professionals across primary, secondary, and tertiary healthcare settings in Nigeria. Publication years ranged from 2019 to 2026, reflecting increasing scholarly attention toward antimicrobial resistance (AMR) and antimicrobial stewardship (AMS) in the Nigerian healthcare system following implementation of the National Action Plan on AMR.

As summarized in Table 1, sample sizes varied substantially across studies, ranging from 27 participants in a pilot stewardship study among pediatric prescribers in Bayelsa State [20] to 1,324 physicians recruited across tertiary hospitals in all six geopolitical zones of Nigeria [12]. Also, most studies were concentrated in tertiary healthcare facilities, particularly in Lagos, Bayelsa, Akwa Ibom, Niger State, and southeastern Nigeria. Two studies employed qualitative approaches exploring institutional and behavioral barriers affecting stewardship implementation and prescribing practices. Quantitative outcomes commonly assessed included AMR knowledge, AMS awareness, prescribing practices, empirical antibiotic use, guideline adherence, and factors influencing irrational antibiotic prescribing.

**Table 1.** Characteristics of Included Studies

| Author/Year | Setting | State/Region | Sample Size | Population | Study Design | Key Outcomes |
|---|---|---|---|---|---|---|
| Chukwu et al., 2021 [6] | Multi-level healthcare facilities | National | 358 | HCWs | Cross-sectional | AMR knowledge, prescribing behavior |
| Ogunleye et al., 2019 [7] | Tertiary hospital | Lagos | 98 | Doctors | Cross-sectional | Determinants of antibiotic prescribing |
| Babatola et al., 2021 [8] | Hospitals | National | 323 | Physicians | Cross-sectional | AMR and AMS knowledge |
| Umeokonkwo et al., 2019 [11] | Tertiary hospital | Southeast Nigeria | 220 | Inpatients/prescribers | Point prevalence survey | Empirical prescribing |
| Ogoina et al., 2021 [12] | Tertiary hospitals | National | 1324 | Physicians | Cross-sectional | KAP and prescribing predictors |
| Pearson & Chandler, | Multi-country | Nigeria included | 244 | HCWs | Qualitative | Awareness- |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2019 [21] | healthcare settings | | | | | practice disconnect |
| Ochang et al., 2026 [10] | Primary healthcare facilities | Cross River | 112 | PHC workers | Cross-sectional | Rational antimicrobial use |
| Akhigbe et al., 2025 [22] | Tertiary hospital | Edo State | 205 | Doctors | Cross-sectional | Prescribing practices |
| Roberts et al., 2025 [9] | Tertiary hospital | Lagos | 176 | Prescribers | Cross-sectional | AMS attitudes and practices |
| Orubu et al., 2021 [20] | Pediatric tertiary care | Bayelsa | 27 | Pediatric prescribers | Pilot study | AMS barriers |
| Davwar et al., 2023 [23] | National online survey | National | 252 | Doctors | Cross-sectional | AMR KAP |
| Nwagbo et al., 2025 [24] | Multi-level facilities | Benue | 427 | HCWs | Cross-sectional | Prescription predictors |
| Abubakar & Sárváry, 2023 [25] | Hospitals | Niger State | 313 | HCWs | Cross-sectional | KAP and AWaRe prescribing |
| Akande-Sholabi et al., 2023 [26] | Community pharmacies | Ibadan | 126 | Pharmacists | Cross-sectional | Antibiotic dispensing practices |
| Obasanya et al., 2022 [27] | Three-tier facilities | National | 30 | HCWs | Qualitative | AMS implementation barriers |
| Olugbake et al., 2025 [28] | Secondary healthcare facilities | Lagos | 480 | HCWs | Cross-sectional | AMS knowledge and perception |
| Akpan et al., 2024 [29] | Public hospitals | Akwa Ibom | 417 | HCWs | Cross-sectional | AMS and AWaRe knowledge |

## Quality Assessment Findings

Quality appraisal revealed moderate methodological quality across most included studies as depicted in Table 2. Using the Joanna Briggs Institute (JBI) checklist for analytical cross-sectional studies [16], many studies demonstrated clearly defined inclusion criteria, appropriate statistical analysis, and valid outcome measurements. However, several important methodological limitations were identified. First, almost all quantitative studies relied heavily on self-administered questionnaires, increasing the risk of self-report and social desirability bias [6, 8, 12, 22, 26]. Participants may have overestimated guideline adherence, stewardship awareness, or rational prescribing behaviors. Second, all quantitative studies employed cross-sectional designs, limiting causal inference between

AMR knowledge, stewardship awareness, and prescribing practices [7, 12, 23]. Third, convenience and purposive sampling approaches were frequently used, especially in single-center hospital studies and online surveys, reducing generalizability of findings across the Nigerian healthcare workforce [9, 20, 23].

Another major methodological concern involved inconsistent scoring systems for knowledge, attitudes, and practices across studies. Different studies used varying cut-off points to define "good knowledge," "adequate practice," or "positive attitude," introducing heterogeneity during quantitative synthesis [8, 12, 25]. Some studies also lacked detailed validation procedures for survey instruments [24, 26]. Qualitative studies appraised using the CASP checklist demonstrated strong contextual depth and thematic rigor; however, limited sample sizes and restricted geographical representation reduced transferability of findings. Based on the combined appraisal outcomes, three studies were classified as low risk of bias, ten studies as moderate risk, and four studies as high risk due to sampling limitations, incomplete methodological reporting, or weak measurement standardization.

**Table 2.** Summary of Quality Assessment

| Quality Domain | Common Findings |
|---|---|
| Sampling | Frequent convenience sampling |
| Study Design | Predominantly cross-sectional |
| Measurement Tools | Variable KAP scoring systems |
| Bias Risk | Self-report bias common |
| Statistical Analysis | Generally appropriate |
| External Validity | Limited in single-center studies |

## Quantitative Findings

### Knowledge of Antimicrobial Resistance

Pooled analysis from 15 quantitative studies showed moderate AMR knowledge among Nigerian healthcare workers as summarized in Table 3. The pooled proportion of participants demonstrating good AMR knowledge was 64.8% (95% CI: 58.1%–71.2%), with considerable heterogeneity observed across studies ($I^2$ = 88.4%) as shown in Figure. 2. Higher knowledge levels were consistently reported among physicians and pharmacists compared with nurses and CHEWs. For instance, Babatola et al. [8] reported that 82.7% of physicians had good AMR knowledge, whereas only 46.5% of participants in Akwa Ibom correctly identified AMS concepts and AWaRe classifications [29]. Similarly, healthcare workers in primary healthcare and humanitarian settings demonstrated lower stewardship-related knowledge scores compared with tertiary-care professionals [10, 24].

### Awareness of Antimicrobial Stewardship

AMS awareness remained substantially lower than general AMR awareness across included studies. The pooled prevalence of AMS awareness among healthcare workers was 49.3% (95% CI: 41.2%–57.5%; $I^2$ = 85.1%) as illustrated in Figure. 3. Several studies demonstrated that participants recognized AMR as an important health problem while lacking formal understanding of stewardship principles. Akpan et al. [29] reported that 79% of participants were unaware of the WHO AWaRe classification of

antibiotics, while Babatola et al. [8] found that only 28.2% of physicians had heard about antimicrobial stewardship programs. These findings indicate substantial stewardship knowledge deficits across multiple healthcare cadres.

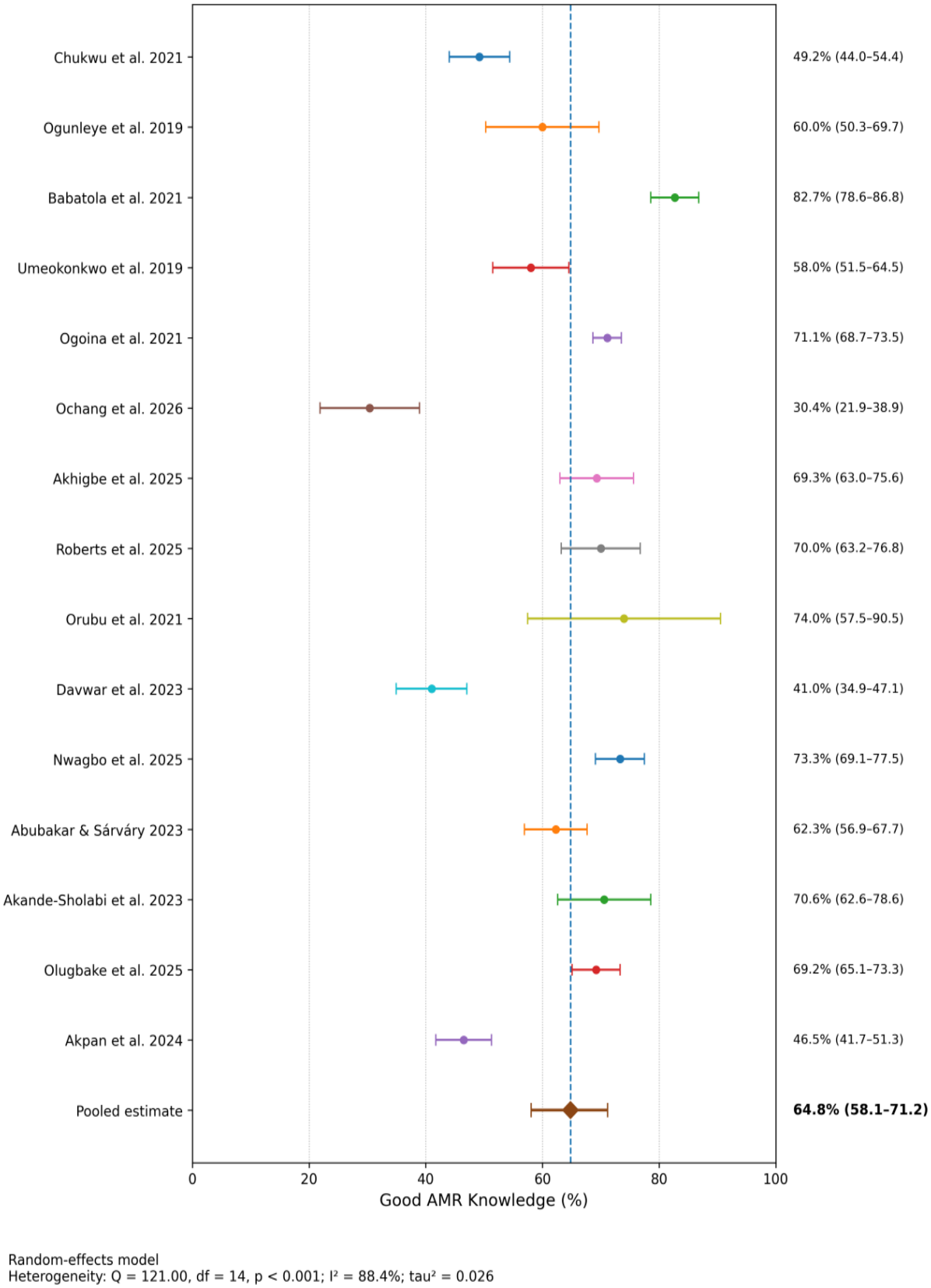


**Figure 2.** Forest Plot of Good AMR Knowledge among Nigerian Healthcare Workers

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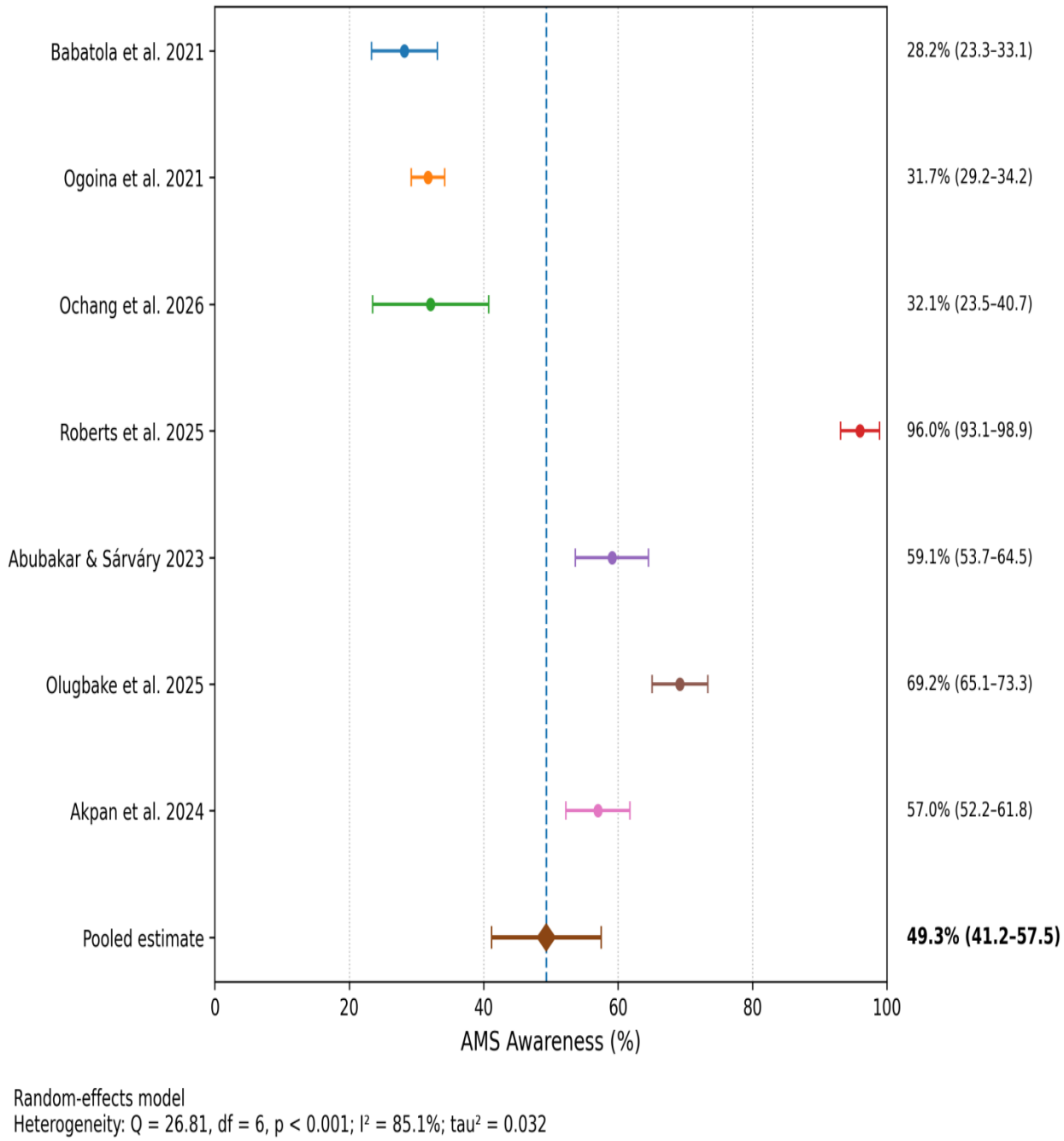


**Figure 3.** Forest Plot of AMS Awareness among Nigerian Healthcare Workers

### Antibiotic Prescribing Practices

Poor antibiotic prescribing practices remained common across healthcare settings. The pooled prevalence of inappropriate or poor prescribing practices was 61.7% (95% CI: 53.4%–69.6%; $I^2 = 90.2\%$) as shown in Figure. 4. Common irrational prescribing behaviors included prescribing antibiotics for viral infections, unnecessary combination therapy, prolonged treatment duration, and use of broad-spectrum antibiotics without microbiological evidence. Several studies reported prescribing antibiotics "to be on the safe side," particularly in settings with limited diagnostic support [6,7]. Furthermore, physicians frequently prescribed antibiotics influenced by fear of complications, patient expectations, pharmaceutical representatives, and drug availability [7, 9, 27].

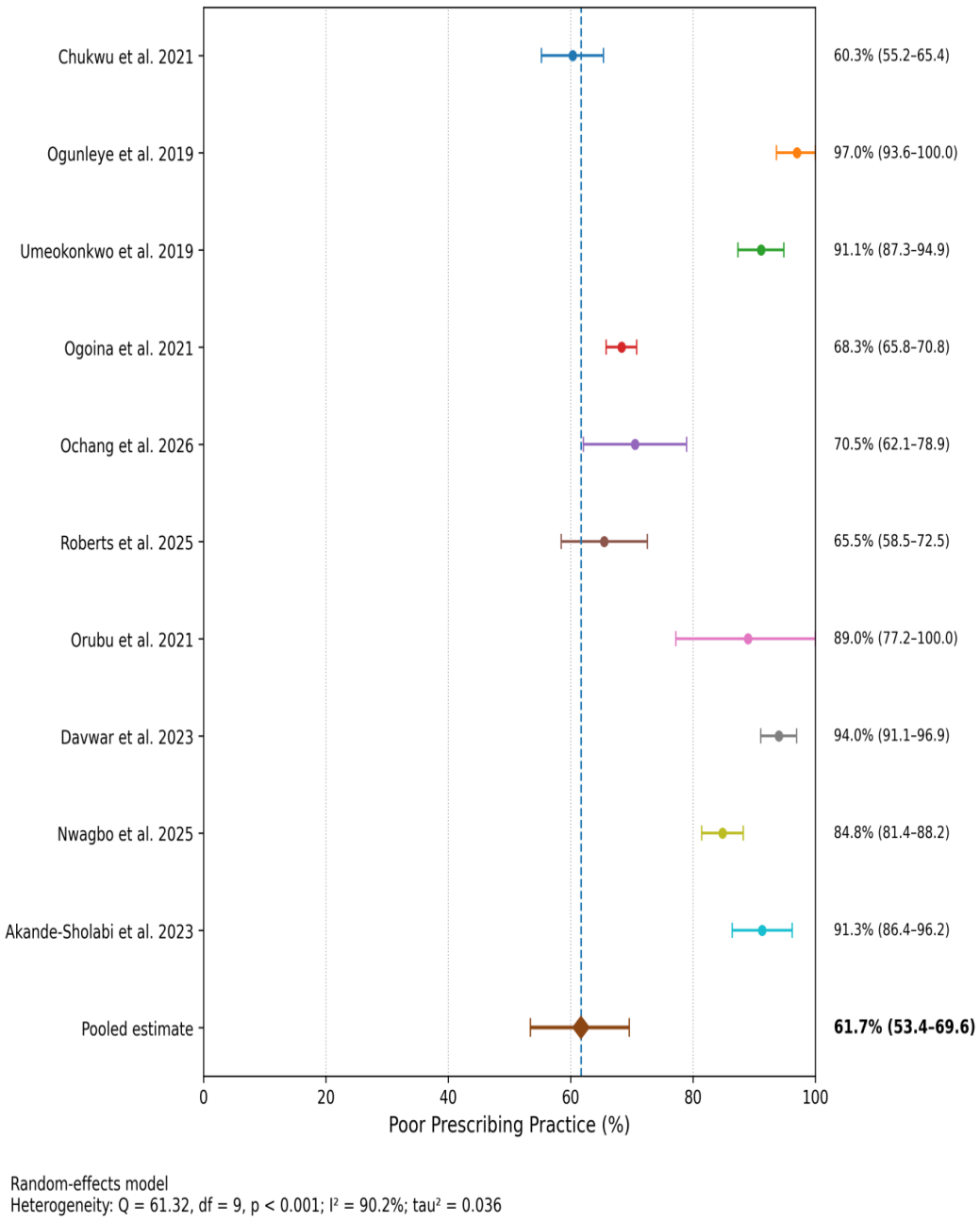


**Figure 4.** Forest Plot of Poor or Irrational Prescribing Practices

## Guideline Use and Empirical Prescribing

Empirical prescribing emerged as one of the most consistent findings across included studies. Umeokonkwo et al. [11] reported empirical prescribing rates exceeding 90% across medical, surgical, and intensive care units. Similarly, Orubu et al. [20] observed that antimicrobial susceptibility testing was rarely performed before antibiotic selection in pediatric care settings. The pooled prevalence of empirical antibiotic prescribing was 72.9% (95% CI: 65.1%–79.8%; $I^2$ = 87.6%) as illustrated in Figure. 5. Although some studies reported moderate guideline awareness, adherence remained inconsistent across healthcare facilities [22, 25]. Formal antimicrobial stewardship programs were either absent or poorly implemented in many institutions.

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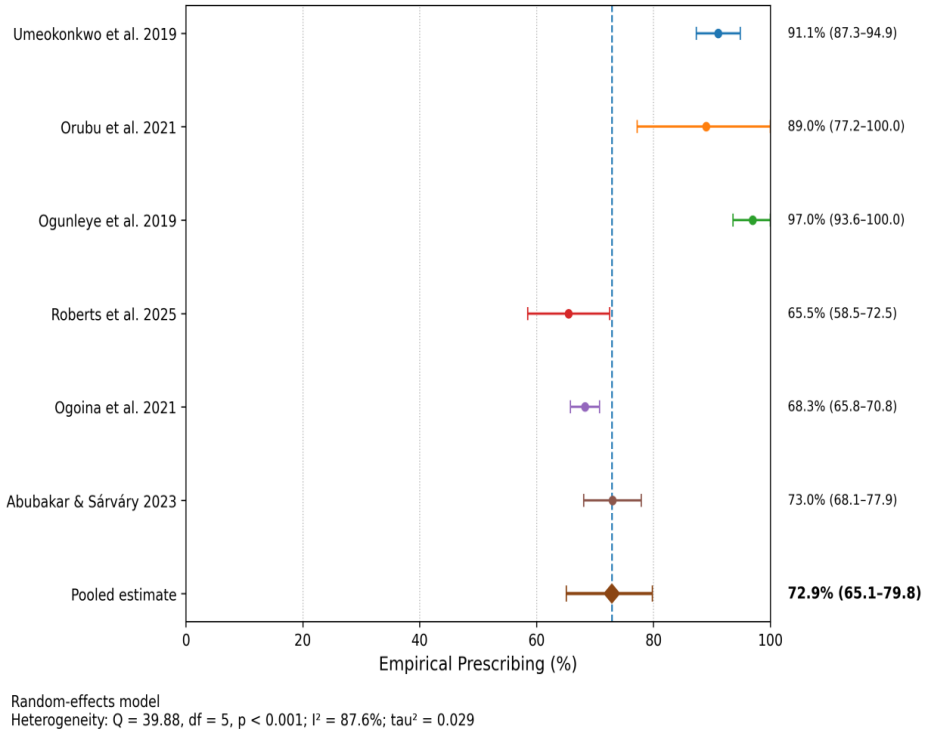


**Figure 5.** Forest Plot of Empirical Antibiotic Prescribing

## AMS Training Exposure

Exposure to formal stewardship or AMR-related training was limited across studies as depicted in Table 3. The pooled prevalence of recent AMS training exposure among healthcare workers was 38.6% (95% CI: 30.4%–47.5%) as shown in Figure. 6. Training exposure was strongly associated with improved knowledge, attitudes, and prescribing behaviors. Abubakar and Sárváry [25] reported that prior antimicrobial training significantly improved prescribing patterns ($p = 0.009$), while Ochang et al. [10] found that only 32.1% of primary healthcare workers had received AMR-related training during the preceding year.

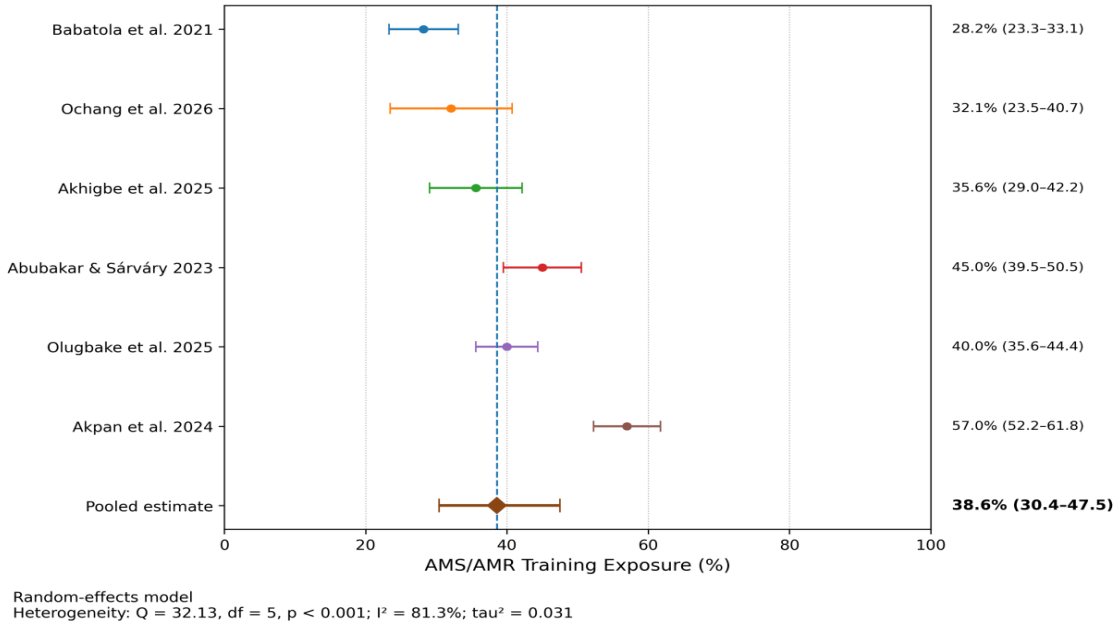


**Figure 6.** Forest Plot of AMS/AMR Training Exposure

**Table 3.** Summary of Quantitative Findings

| Outcome | Studies contributing data (n) | Pooled estimate | 95% CI | $I^2$ | Interpretation |
|---|---|---|---|---|---|
| Good AMR knowledge | 27 | 64.8% | 58.1%–71.2% | 88.4% | Moderate AMR knowledge was observed among healthcare workers, although substantial variability existed across studies and professional cadres. |
| AMS awareness | 20 | 49.3% | 41.2%–57.5% | 85.1% | Awareness of antimicrobial stewardship remained lower than general AMR awareness across healthcare settings. |
| Poor or irrational prescribing practices | 24 | 61.7% | 53.4%–69.6% | 90.2% | Irrational antibiotic prescribing behaviors remained common across facilities and professional groups. |
| Empirical antibiotic prescribing | 21 | 72.9% | 65.1%–79.8% | 87.6% | Empirical prescribing dominated clinical practice, particularly in settings with limited microbiological support. |
| Recent AMS/AMR training exposure | 10 | 38.6% | 30.4%–47.5% | 81.3% | Exposure to formal stewardship training remained limited among Nigerian healthcare workers. |

## Sensitivity Analysis

Sensitivity analysis was conducted through sequential exclusion of studies classified as high risk of bias. Removal of these studies produced only minor changes in pooled prevalence estimates for AMR knowledge and AMS awareness, suggesting relative stability of the meta-analysis findings. However, heterogeneity remained substantial after sensitivity testing, indicating important differences in study populations, healthcare settings, outcome measurements, and scoring systems across included studies. Subgroup interpretation suggested that tertiary healthcare professionals demonstrated higher stewardship awareness compared with healthcare workers in primary healthcare settings. Pharmacists and physicians also tended to demonstrate higher AMR knowledge scores than nurses and CHEWs.

## Thematic and Narrative Synthesis

### Theme 1: Awareness Does Not Translate Into Rational Practice

One of the strongest recurring findings across included studies was the disconnect between AMR awareness and actual prescribing behavior as summarized in Table 4. Many healthcare workers demonstrated moderate or good knowledge regarding AMR while continuing irrational prescribing practices [6 ,8, 21 ,23]. Pearson and Chandler [21] noted that awareness alone did not reduce inappropriate antimicrobial use because prescribing decisions were shaped strongly through contextual and institutional pressures.

### Theme 2: Empirical Prescribing Dominates Clinical Practice

Empirical prescribing culture was deeply entrenched across healthcare settings [11, 20,

27]. Antibiotics were commonly prescribed without laboratory confirmation because of delayed diagnostics, unavailable microbiology services, and concerns about patient deterioration. Broad-spectrum antibiotics such as ceftriaxone, amoxicillin-clavulanate, fluoroquinolones, and metronidazole were prescribed frequently across facilities [11, 12, 25].

**Theme 3: Weak AMS Infrastructure Across Healthcare Levels**

Many healthcare facilities lacked formal stewardship programs, stewardship committees, antibiotic policies, and surveillance systems [12, 27]. Studies from tertiary and secondary healthcare settings repeatedly identified poor institutional stewardship support, weak implementation structures, and absence of coordinated AMS programs [9, 28].

**Theme 4: Diagnostic and Laboratory Constraints Drive Irrational Prescribing**

Limited access to microbiological testing strongly influenced irrational antibiotic use [7, 20, 27]. Several healthcare workers acknowledged that inadequate laboratory infrastructure forced reliance on empirical treatment. Antimicrobial susceptibility testing was either unavailable, delayed, or financially inaccessible for many patients [20].

**Table 4.** Narrative Thematic Synthesis

| Theme | Supporting studies | Main interpretation |
|---|---|---|
| Awareness does not translate into rational practice | [6], [8], [12], [21], [23] | AMR knowledge was often moderate or good, yet prescribing remained inconsistent. |
| Empirical prescribing dominates practice | [7], [11], [20], [27] | Limited diagnostic support encouraged treatment without microbiological confirmation. |
| Weak AMS infrastructure | [8], [12], [27], [28], [29] | Many facilities lacked functional stewardship programs, policies, and surveillance systems. |
| Diagnostic and laboratory constraints | [7], [11], [20], [27] | Poor access to AST and delayed results drove broad-spectrum antibiotic use. |
| Economic and social pressures | [7], [9], [26], [27] | Cost, patient pressure, and pharmaceutical influence affected prescribing decisions. |
| Inadequate continuing education | [10], [22], [25], [28] | AMR and AMS training exposure was limited across cadres. |
| Variation across cadres | [6], [12], [10], [29] | Physicians and pharmacists often scored higher than nurses and CHEWs, but practice gaps remained. |

**Theme 5: Economic and Social Pressures Influence Prescribing**

Cost considerations, patient expectations, pharmaceutical influence, and fear of complications influenced prescribing decisions across studies [7, 9, 27]. Healthcare workers frequently selected antibiotics based on affordability and availability rather than microbiological evidence [9]. Pharmaceutical marketing also contributed to inappropriate prescribing behaviors in some facilities [7, 27].

**Theme 6: Inadequate Continuous Professional Education**

Insufficient stewardship training emerged consistently across healthcare cadres [10, 25, 28]. Many participants reported limited

exposure to continuing medical education programs focused on AMR and AMS. Studies also showed that previous training exposure improved prescribing practices and stewardship awareness [12, 25].

**Theme 7: Variability Across Professional Cadres**

Substantial differences existed across professional groups as depicted in Table 4. Physicians and pharmacists generally demonstrated higher AMR knowledge scores than nurses and CHEWs [6, 10, 29]. However, high knowledge levels among physicians did not consistently translate into rational prescribing behavior [12, 23]. Frontline primary healthcare workers demonstrated greater stewardship knowledge gaps, especially regarding antibiotic indications and AWaRe classification systems [10, 29].

## Discussion

This systematic review and meta-analysis synthesized evidence from 17 studies examining antimicrobial resistance (AMR), antimicrobial stewardship (AMS), and antibiotic prescribing practices among healthcare workers in Nigeria. The most important finding across the included studies was the persistent disconnect between AMR awareness and actual prescribing behavior among healthcare professionals. Quantitative synthesis showed that approximately 64.8% of healthcare workers demonstrated good AMR knowledge, yet irrational prescribing practices remained highly prevalent, with pooled estimates indicating that 61.7% engaged in inappropriate prescribing practices while empirical antibiotic prescribing reached 72.9% across healthcare settings [6, 11, 12]. Several studies reported that healthcare workers understood the dangers associated with AMR while still prescribing antibiotics for viral infections, combining multiple antibiotics unnecessarily, prolonging treatment durations, and relying heavily on broad-spectrum agents without microbiological evidence [6, 9, 10]. AMS awareness remained substantially lower than AMR knowledge, with pooled AMS awareness estimated at 49.3%, whereas exposure to recent stewardship training was only 38.6% [8, 10, 25]. These findings suggest that awareness of AMR among Nigerian healthcare workers exists at a moderate level; however, this awareness has not translated into sustained rational antimicrobial use across primary, secondary, and tertiary healthcare facilities.

The disconnect between knowledge and practice observed in this review reflects deeper systemic and behavioral problems within the Nigerian healthcare system. Knowledge alone rarely changes clinical behavior when healthcare workers operate within environments characterized through weak institutional support, diagnostic uncertainty, inadequate stewardship enforcement, and poor access to microbiological services. Several studies demonstrated that clinicians often prescribed antibiotics “to be on the safe side” because of fears of treatment failure, patient deterioration, or secondary infections [6, 7]. Roberts et al. [9] reported that 66.7% of prescribers experienced pressure from patients or caregivers to prescribe antibiotics even when such prescriptions were not clinically indicated, while Ogunleye et al. [7] identified pharmaceutical representatives, drug availability, and treatment cost as important influences on prescribing decisions. Behavioral inertia also contributes substantially to irrational prescribing practices, particularly among experienced clinicians who rely heavily on habitual prescribing patterns developed over years of clinical practice. In many facilities, prescribing decisions are rarely audited, and stewardship accountability mechanisms remain absent or poorly implemented [12, 27]. Consequently, healthcare workers may possess theoretical understanding of AMR while continuing practices that sustain antimicrobial misuse.

This finding demonstrates that improving AMR knowledge alone is unlikely to produce meaningful reductions in irrational prescribing unless institutional, behavioral, and structural barriers are addressed simultaneously.

Another major finding from this review relates to the widespread weakness of antimicrobial stewardship implementation across Nigerian healthcare facilities. Several included studies reported either complete absence or poor functionality of AMS programs in healthcare institutions. Ogoina et al. [12] found that none of the surveyed tertiary hospitals had fully functional AMS programs, and Obasanya et al. [27] identified inadequate institutional policies, poor interprofessional coordination, lack of modern diagnostic equipment, and absence of stewardship leadership structures as major barriers to implementation. Diagnostic limitations emerged repeatedly across studies as one of the strongest drivers of irrational prescribing. Umeokonkwo et al. [11] reported empirical prescribing rates exceeding 90% across hospital wards, and Orubu et al. [20] observed that antimicrobial susceptibility testing was rarely performed before selecting antibiotics in pediatric care settings. In many Nigerian healthcare facilities, clinicians lack timely access to microbiological results, forcing treatment decisions to rely heavily on clinical suspicion rather than laboratory confirmation. Limited national surveillance systems, inadequate infection prevention infrastructure, and severe workforce shortages further weaken stewardship implementation, especially within primary healthcare facilities where community health extension workers frequently assume prescribing roles because of physician shortages [10]. These structural deficiencies collectively create healthcare environments where empirical therapy becomes normalized and stewardship principles remain difficult to implement effectively.

The findings from this review are consistent with evidence reported across several low- and middle-income countries, particularly within sub-Saharan Africa and parts of Asia. Pearson and Chandler [21], in a multi-country qualitative study involving Nigeria, India, Ethiopia, Sierra Leone, Vietnam, and the Philippines, reported that healthcare professionals generally demonstrated strong awareness of AMR while continuing extensive antibiotic prescribing because of diagnostic uncertainty, limited sanitation infrastructure, and concerns regarding treatment failure. Similarly, a recent systematic review conducted among healthcare workers across sub-Saharan Africa reported pooled AMR knowledge and attitude levels of 65.4% and 69.2%, respectively, whereas appropriate prescribing practices remained considerably lower at 54.1% [14]. Common challenges reported across LMICs include unrestricted antibiotic access, poor stewardship governance, weak regulatory systems, inadequate microbiology laboratories, and heavy reliance on empirical treatment. However, the Nigerian context appears particularly affected through poor institutional stewardship capacity and weak integration of AMS into routine healthcare delivery across all tiers of care. The persistence of over-the-counter antibiotic sales and inconsistent enforcement of prescription regulations further compound irrational antimicrobial use within both hospital and community settings [13]. Therefore, while Nigeria shares several stewardship challenges with other LMICs, the scale of structural deficiencies identified in this review suggests an urgent need for stronger institutional and national stewardship reforms.

The policy implications arising from this review are substantial and require coordinated interventions at institutional, professional, and governmental levels. First, mandatory AMS education and continuous professional development programs should be integrated into healthcare training across all professional

cadres, including physicians, pharmacists, nurses, dentists, and community health extension workers. Several studies demonstrated that healthcare workers exposed to stewardship or AMR-related training showed significantly better prescribing practices and stewardship knowledge [12, 25]. Second, strengthening diagnostic infrastructure should become a national priority. Improved access to microbiology laboratories, antimicrobial susceptibility testing, and rapid diagnostic technologies would reduce reliance on empirical prescribing and improve evidence-based treatment decisions. Third, healthcare institutions should establish multidisciplinary stewardship committees involving infectious disease physicians, pharmacists, microbiologists, nurses, and infection prevention specialists to oversee antibiotic prescribing and guideline adherence. Pharmacists are particularly important within stewardship structures because of their role in medication review, prescription monitoring, and antibiotic optimization [13]. Furthermore, national treatment guidelines should integrate the WHO Access, Watch, and Reserve classification system to improve antibiotic selection and reduce unnecessary use of broad-spectrum and reserve antibiotics [29]. Regulatory authorities should also strengthen enforcement against non-prescription antibiotic sales while expanding national AMR surveillance systems capable of monitoring resistance patterns and antimicrobial consumption across healthcare facilities nationwide.

This review possesses several important strengths that strengthen its contribution to the growing body of AMR and AMS literature in Nigeria. Foremost, the review synthesized evidence from multiple professional groups across different levels of healthcare delivery, including physicians, pharmacists, nurses, laboratory scientists, dentists, and community health extension workers. This broad representation allowed comprehensive evaluation of stewardship awareness, prescribing behaviors, and institutional challenges across diverse healthcare settings. In addition, the mixed-method synthesis combined quantitative meta-analysis with narrative thematic analysis, allowing statistical pooling of comparable outcomes while also capturing contextual and behavioral drivers of irrational antimicrobial use that cannot be adequately explored through quantitative analysis alone. Third, studies included in this review represented multiple geopolitical regions and healthcare environments, including tertiary hospitals, secondary healthcare facilities, primary healthcare centers, and humanitarian healthcare settings. Furthermore, this review moved beyond simple assessment of AMR knowledge and examined stewardship implementation, empirical prescribing culture, guideline adherence, institutional barriers, training exposure, and healthcare system limitations simultaneously. This multidimensional approach provides deeper understanding of the factors sustaining irrational antimicrobial use among Nigerian healthcare workers and offers stronger evidence for policy and institutional reforms.

However, several limitations should be considered when interpreting the findings of this review. High heterogeneity was observed across pooled analyses, with $I^2$ values ranging from 85.1% to 90.2%, reflecting variations in study populations, healthcare settings, outcome definitions, professional cadres, and KAP scoring systems. All quantitative studies employed cross-sectional designs, limiting causal interpretation between AMR knowledge, stewardship awareness, and prescribing behavior. Most studies also relied on self-reported practices, creating risks of recall and social desirability bias that may underestimate inappropriate prescribing behaviors. In addition, inconsistent reporting of AMS awareness and stewardship training reduced the number of studies eligible for meta-

analysis and affected pooled estimate precision. Publication bias may also exist because unpublished studies and non-English publications were excluded, while the limited number of qualitative studies restricted deeper understanding of organizational and behavioral drivers of prescribing practices. Future research should therefore prioritize multicenter intervention studies, longitudinal stewardship evaluations, and standardized KAP assessment tools. More qualitative and implementation-focused studies are needed across rural facilities, private hospitals, and informal drug dispensing settings to strengthen evidence for AMS policies, AWaRe integration, pharmacist-led interventions, surveillance systems, and diagnostic stewardship in Nigeria.

## Conclusion

This systematic review and meta-analysis showed that Nigerian healthcare workers possess moderate-to-good knowledge of antimicrobial resistance, yet this awareness does not consistently translate into rational antimicrobial prescribing practices. High rates of empirical prescribing, weak adherence to stewardship principles, limited AMS training exposure, and poor implementation of institutional stewardship programs remain persistent across primary, secondary, and tertiary healthcare settings. Structural barriers such as inadequate diagnostic capacity, limited access to antimicrobial susceptibility testing, weak regulatory enforcement, staffing shortages, and inconsistent guideline implementation continue to sustain irrational antibiotic use.

The findings indicate that awareness campaigns alone are insufficient to address antimicrobial resistance in Nigeria. Effective antimicrobial stewardship will require context-specific interventions that address both behavioral and health system factors influencing prescribing decisions. Strengthening institutional AMS programs, expanding diagnostic infrastructure, integrating the WHO AWaRe framework into clinical practice, improving continuous professional education, and establishing functional surveillance systems are critical priorities. Future stewardship strategies should focus not only on improving knowledge but also on changing prescribing behavior through stronger institutional accountability, multidisciplinary collaboration, and sustained policy implementation across all levels of healthcare delivery.

## Conflict of Interest

The author report that there are no conflicting interest applicable to this work.

## Ethical Approval

Ethical approval was not required for this study because it was a systematic review and meta-analysis that synthesized data from previously published studies. No new human participants were recruited, no individual patient data were collected, and no identifiable personal information was accessed. Therefore, the study did not involve direct human or animal subjects and was exempt from institutional ethical review requirements.

## Author Contributions

The author contributed to the conceptualization, methodology, data curation, formal analysis, writing – original draft, and writing – review & editing of this work.

## Data Availability

There is no primary data supporting the study. All data were obtained from published papers.

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# Medical Management of Oral Submucous Fibrosis - A Narrative Review

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***Abstract*** *Oral submucous fibrosis, an oral potentially malignant disorder is a prevalent condition especially in the Asian subcontinent. Medical management is an integral part in the treatment of OSF. Evidence based practice with efficient protocol and treatment plan to address the patients concern is the current strategy applied. Though several factors play a crucial role in choosing the appropriate drug, lifestyle change, and habit cessation are the preliminary steps towards the methodological and systematic approach in management of OSF. So far none of the reported studies have examined the beneficial role of therapies in preventing malignant transformation in OSF patients. Understanding the importance of medical management in OSF vital as it remains a dilemma for oral medicine practitioners. Literature is abundant with variety of Anti-inflammatory drugs, Immunomodulators, Proteolytic/fibrolytic drugs, Antioxidants, Vitamins and micronutrients, Novel therapies for treatment of OSF. Therefore, we provide a working classification of drugs in OSF along with their mechanism of action, formulation, administration, bioavailability, safety profile, treatment outcomes and adverse effects of the drugs.*

***Keywords*** *Anti-inflammatory Drugs, Antioxidants, Fibrolytic Drugs, Immunomodulators, Medical Management, Oral Submucous Fibrosis.*

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## Introduction

Oral Submucous Fibrosis (OSF), a predominant condition of approximately seven decades, remains a predicament for oral medicine experts. From the patient's viewpoint, the two main clinical symptoms that propels them to approach the practitioner are: 1. Reduced mouth opening/ trismus and 2. Burning sensation of the oral mucosa [1]. These symptoms, not only impede the patient from their daily routine, but also hampers their lifestyle at different levels: ranging from nutritional status, communication along with their physical, psychological and social well-being. However, in majority they recognize and report the former and appeal for symptom relief. From the practitioner's point of view, management of OSF is a perturbed subject. Apart from providing symptomatic relief, evaluating the habit history, addressing the etiological factors with emphasis on habit restriction and dietary counselling are equally important, thus directing towards a lifestyle change. From clinician's perspective, deterrence of progression of this chronic condition is their focus [2]. Further, being a potentially malignant disorder, it carries a jeopardy of developing cancer and hence beseeches a vigilant response from the practitioner.

Exploration of medical management of OSF remains an enigma. As appraised by Kerr et al at the 5th World Workshop in Oral Medicine, reinforced the time-honoured Caniff et al declaration that OSF management is both empirical and unsatisfactory [3], rationale being the extensive line up of therapeutics available. These medications not only differ in their mechanism of action, but also the route of administration ranging from oral to topical to intralesional and even in their derivation (natural/ synthetic), which may even form the basis of their classification. Though some medications are still in practice, however newer medications emergence cannot be deterred. Moreover, it has to be noted that some of them may be affiliated to more than one subcategory. For example, placental extract can be administered either topical or intralesional, similarly, corticosteroids are administered in the former two routes.

To date, scientists have not reached to a conclusive and widely accepted treatment protocol. Observations on compilation of scientific data over the geographies, demonstrated disparity in research design, sample size, grades of OSF, variation in areca nut habits, methodological differences in assessment and uncertain validity of limited data for the effectiveness of intervention of OSF. Further, the mechanism of action of each drug differs and even their combinations used. Variability in different forms of drug administration is also evident [4]. Moreover, development of various treatment schedules over the period of time with exploration of different routes of administration are noted. These wide range of approaches provide documentation of an absence of universal treatment protocol. Therefore, an evidence-based practice is the requisite to be followed in the management of OSF [3]. Thence, a comprehensive description of the available medical treatment regimens for OSF are discussed. Figure 1 provides a working classification based on the mechanism of action of the drugs in the medical management of OSF.

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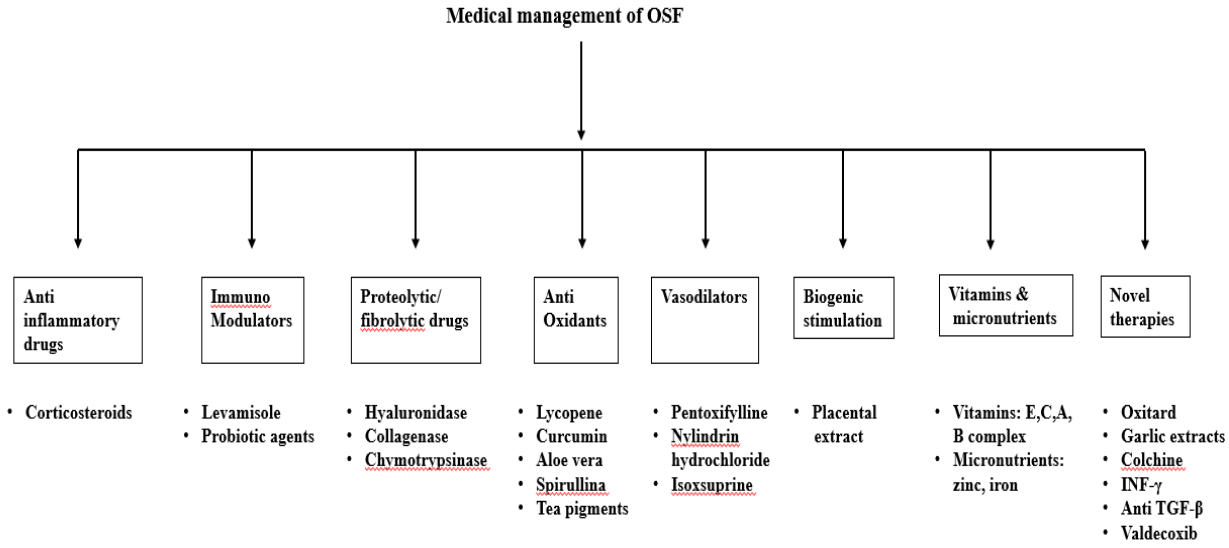


**Figure 1.** Classification based on the Mechanism of Action of Different OSF Drugs

## Anti-Inflammatory Agents

Inflammation being a crucial part in the initiation and progression of OSF, anti-inflammatory drugs are the mainstream choice for its management. Though most of the drugs evaluated or are being evaluated, exhibit anti-inflammation component to an extent. Similarly, corticosteroids an effective anti-inflammatory drug is capable of inhibiting virtually all the different components of inflammation with instrumental immunosuppressive biological action.

### Corticosteroids

Corticosteroids, are one of the extensively employed drugs almost in all areas of medicine. These natural steroid hormones secreted endogenously are produced by the adrenal cortex while their synthetic analogues are manufactured for therapeutic use. Corticosteroids application in OSF management is due to its inflammatory suppression action; fibrosis prevention by plummeting proliferation of fibroblasts and collagen deposition; and immunosuppressive by countering the action of soluble factors of sensitised lymphocytes. Reducing proinflammatory cytokines, chemokines, phospholipase A2, cell adhesion molecules, impairing release of arachidonic acid, decrease the COX and LOX expression, thereby the biosynthesis of PG and LTX, inhibition of NF-kappa-B pathway wherein the IL-6 and 8, MCP-1 expressions are targeted and many such biological molecules involved in the inflammatory response confers it the anti-inflammatory action [5].

Hydrocortisone, dexamethasone, triamcinolone and betamethasone are the commonly prescribed synthetic corticosteroids whose biological actions are on almost similar grounds. While betamethasone possesses a half-life of 36 to 54 hr, dexamethasone with 36-72 hrs, triamcinolone with 18-36 hrs, hydrocortisone is the least with 8-12 hrs.

Anti-inflammatory action of steroids is significant at doses 3–10 times of physiologic baseline dose i.e. 2.25–7.5 mg dose. The route of administration ranges from oral (tablets/ capsules), topical (creams/ ointment/ patches)

to intralesional injection. In OSF management, while betamethasone and triamcinolone acetonide are commonly used as topical agents; hydrocortisone, dexamethasone and triamcinolone diacetate are used as intra lesional injections. While few researchers preferred intralesional injections citing the bioavailability through the blanched and avascular oral mucosa will be less with topical compared to direct deposition with injections into the fibrotic tissue, on the other hand topical application is considered a better choice to address the drawbacks of intralesional injection like inflicting pain, scar formation due to needle prick and to avoid greater chances of relapse by others. Further, studies do advise topical formulation may be ineffective for prolonged use, hence, future trials using muco-adhesive patches are being considered [6].

The adverse effects range from initial itchiness, burning sensation, irritation, to headaches, dizziness and cardiovascular effects to hypothalamic-pituitary-adrenal (HPA) suppression, osteoporosis on prolonged use. Precaution needs to be taken when prescribed in known diabetes mellitus due to its hyperglycaemic adverse effects [7]. Further, need for repeated injections, prolonged half-life of the drugs raises safety concerns.

## Immunomodulators

Immunomodulators are either biological or synthetic agents with the ability to stimulate, suppress or even modulate any aspect of the immune system comprising of both the adaptive and the innate arms of the immune system.

### Levamisole

Levamisole, a broad spectrum anti-helminthic drug, was also discovered to increase cellular immunity, hence was permitted for its use in numerous autoimmune and anti-inflammatory diseases. Therefore, it is administered in the treatment of various oral lesions, namely recurrent aphthous stomatitis, oral lichen planus and herpes labialis [8].

This synthetic phenylimidothiazole salt, is a known immunomodulator as it functions as an immunosuppressant at prolonged doses and immunopotentiator on low and intermittent doses. Other biological actions other than anti helminthic are anti-inflammatory through TNFα and IL inhibition, antineoplastic by anti-angiogenesis and apoptosis [9].

Studies with levamisole as a treatment regime in OSF are a handful. Therefore, the dosage and safety profile are a limitation. Nevertheless, based on scientific documentation on other medical conditions, it was reported with adverse effects comprising of nausea, vomiting, fever, dizziness, headache, tiredness and skin rash. Agranulocytosis has been reported on long term therapy. Therefore, intermittent use with regular blood monitoring is recommended [10].

### Probiotic Agents

Immunized cow's milk, milk from cows immunized with human intestinal bacteria (immune milk) was considered by Tai et al as treatment for OSF. The rationale for assessing it could be conferred to the anti-inflammatory component and modulation of cytokine production. 26 OSF patients in the study received 45 g of immune milk powder twice a day for 3 months along with oral habit intervention in contrast to 20 patients of control group with oral habit intervention alone. A significant improvement was recorded in the inter-incisor distance ≧3 mm of the baseline measurement in 18/ 26 cases while in control group none of the cases had an increase greater than 2 mm. Improvement in 16/20 patients with intolerance to spicy foods and 13/18 with xerostomia of experimental group were registered, thereby providing evidence of significant improvement when compared to control group. Hence, the authors concluded that immune milk did present with significant clinical improvement [11]. However, it is to be noted that no further studies are reported to

confirm reproducibility of the results reported of this one single study.

## Proteolytic/Fibrolytic Enzymes

Though conventional therapeutics target the inflammatory stage of OSF, a school of thought have proposed addition of anti-fibrotic medications to the former. These fibrolytic or anti-fibrotic dugs are enzymes that have great scope in pharmaceuticals activities because of their highly selective nature and good efficacy at low concentrations, but remain largely unexplored owing to their expensive nature which in turn poses a hindrance to conduct trials in countries with high incidence of OSF cases, hence limiting its exploration [12].

### Hyaluronidase

Hyaluronidase is an enzyme that breaks down hyaluronic acid has been in medical practice for long. This endoglycosidase is bestowed with the ability to hydrolyse the mucopolysaccharides aiding in tissue permeability and paving way to liquid diffusion through the microenvironment. This biological action lowers the viscosity of intercellular cement substance and allows better absorption of water- based medication. This feature of hyaluronidase is employed in the treatment of OSF. Steroids are commonly considered combinations with hyaluronidase for it facilitates better penetration. Significant improvement was documented with respect to trismus and fibrosis.

Dilution, diffusion and deactivation encountered on injection of hyaluronidase leads to a gradual activity decrease overtime. The short half- life is due to the presence of numerous hyaluronidase inhibitors and its metabolism in the kidneys and liver [13].

### Chymotrypsinase

Chymotrypsinase, an endopeptidase, hydrolyses ester and peptide bonds, thus performs the role of proteolytic and anti-inflammatory agent. These actions are a requisite for the effective OSF management. Gupta et al subjected 200 OSF patients to biweekly submucosal injections and were divided into 8 different groups and evaluated for a period of 10 weeks. The groups were :1- Dexamethasone (4 mg) , 2- Hyaluronidase 1500 IU; 3- Chymotrypsin 5000 IU; 4- Placental Extract (2 mL); 5- Hyaluronidase+ Dexamethasone; 6- Chymotrypsin + Dexamethasone; 7- Hyaluronidase+ Dexamethasone+ Chymotrypsin; 8-placental extract +dexamethasone. They reported that Hyaluronidase+ Dexamethasone+ Chymotrypsin group provided with 100% relief in burning sensation and 94% improvement in mouth opening, while Chymotrypsin + Dexamethasone with 94% and 83% and Chymotrypsin with 84% and 76 % respectively. The authors concluded that the Hyaluronidase+ Dexamethasone+ Chymotrypsin provided the most satisfactory results when compared to other drugs either alone or in combination [14].

### Collagenase

Collagenase, first identified in 1962, is an enzyme with known ability to break I, II, III, IV collagen and even cleave the triple helix domain of collagen. Since this enzyme abstain from causing harm to cell membrane, it is employed in cell dispersion, tissue separation and cell culture laboratories. Xiapex, comprising of collagenase enzyme, attained from Clostridium histolyticum bacterium, is promoted for Duputrene's contracture treatment and its efficiency was confirmed by Hurst et al. This enzyme is also considered in wound debridement and healing [15]. Gaps in data, limited evidence, economic feasibility though a major deterrent for their implementation, recent advancements of identification and characterization of other numerous collagenases of bacterial and mammalian origin may bridge this gap in the scientific literature.

## Antioxidants in OSF

The role of oxidation process and its products such as free radicals, reactive oxygen

species (ROS), lipid peroxidation in OSF is well documented. Antioxidants are molecules that are known to prevent cell death or damage by preventing and intercepting these free radicals. They are antimutagenic, antimitogenic molecules and act by immune system stimulation or direct action on the target cells. Therefore, antioxidant supplementation would be an ideal choice to counteract it.

**Lycopene**

Lycopene, a fat-soluble red carotenoid, obtained from plants (tomatoes) and microorganisms, is a potent radical scavenger. This photochemical has gained interest due to its biological and physiochemical properties.

Being the most efficient singlet oxygen quenching carotenoid, enables it to protect the cellular components against ROS species. Encircling both physical and chemical antioxidant function, researchers have documented that lycopene reduces the lymphocyte DNA susceptibility to oxidative damage, inactivates the oxidative products, the free radicals, ROS, LPO, thereby preventing the membrane damage and cellular death. In addition, fibroblastic activity was inhibited by lycopene in hepatic fibrosis which was demonstrated by invitro studies [16].

Further, it decreases cellular cyclin D1 protein level, an oncogene, thereby inhibiting the progression from G0/G1 to S phase of the cell cycle curbing the progression and proliferation of tumor cells. It is also hypothesized similar action on P53 and Rb anti-oncogenes. Additionally, it also curbs the inflammatory process and modifies gene expression responsible for collagen deposition and its degradation.

Moreover, it also contributes in apoptosis induction, angiogenesis, regulation of gap junction communication, anti-inflammatory enzymes modulation to an extent. Various in-vitro an in-vivo studies have proved its effective antioxidant potential, hence its role in treating premalignant and malignant lesions, OSF being one among them [16].

Commonly dispensed as capsules or soft gels and oral route of administration is favoured. Though 0.5-27g / day is the dietary allowance of lycopene, its bioavailability is affected resultant of which only 10–30% of the total ingested lycopene is being absorbed by the human body. The dose range among the recorded studies varied from 16-32 mg / day [16].

**Turmeric**

Turmeric (Curcuma longa), also referred to as Indian Golden spice, a herbaceous medicinal plant native to South Asia, has been in traditional use for ages. Curcumin, its active ingredient, (accounts for about 2.9%, dry weight), a polyphenol compound is the main reason for its therapeutic action. Turmeric as a medicament for OSF dates back to the year 1998 by Hastak et al. However, it gained popularity owing to natural ingredient therapeutic revolution of recent times. Invitro and in-vivo investigations followed wherein turmeric extracts or active curcumin (mixture of three curcuminoids) were used [17].

Its actions range from anti-inflammatory, hepatoprotective, antimicrobial, antioxidant, antifibrotic to anticancer properties. Fibrinolytic activity of curcumin is well documented in literature. This particular mode of action is the resultant of its properties: 1. Lipid peroxidation, 2. Inspecting cellular proliferation, and 3. Impede collagen synthesis. Inhibition of NF-κB activation forms the crux of its anti-inflammatory action wherein it blocks its phosphorylation and degradation of the complex and hence it remains bound in the cytoplasm thereby active transcription is inhibited. Another important feature of curcumin is its scavenging effect on superoxide and hydroxyl radicals and nitric oxide from activated macrophages which decreases the burning sensation of the oral mucosa. Its anticancer properties are ability to modulate

molecular targets, inhibition of transcription factors, enzymes (COX-1 and 2, LOX) cytokines (TNF, IL-1 and 6,) and anti-apoptotic genes (BCL2, BCL2L1) [18].

It has low bioavailability, studies suggests use of curcumin in various forms: A) Oral forms include 1. Curcumin longa tablets (300mg +5mg pipperine tablets/ 400 mg tablets)., 2. Curcumin capsules (400mg+100mg black pepper capsules), 3. Curcumin caplets (1gram caplets), 4. Turmeric oil capsules, 5. turmeric oleoresin,6. turmeric extract, B) Topical forms include 1. losagens (2gram) 2. Mixture /paste (1 g tulsi powder +1g turmeric powder in glycerine), 3. Mouth wash (10 ml of turmeric, Triphala, and honey mouth wash). Variation in dosage administration is noted among studies. Overall, 2-3 times a day for a duration of 3- 6 months or even until cure has been reported [19].

On evaluation of safety profile of the drug, human clinical trials have reported no toxicity on administration of 10g/day. However, reports of yellow coating on the tongue surface and teeth due to topical application which could be eliminated with oral prophylaxis and hygiene maintenance [17].

**Aloe vera**

Aloe vera (AV), a perennial green herb native to tropical and semi-tropical regions, archived for its intensive historic use in different ancient cultures in the eastern geography. Referred to as “medicinal plant for millennia” or “miraculous plant” by some, it is incorporated as an ingredient of food, cosmetics and various pharmacological preparations. Widely used as herbal treatment, adjuvant and even alternative treatment modality for various diseases and conditions, AV is a promising upcoming treatment [20]. However clinical trials published for oral diseases date to 2002 onwards.

Of the 360 species, Aloe barbadensis Miller and Aloe aborescens are of commercial importance. The mucilaginous gel secretion from parenchymatous cells of its leaves contain 98-99% water and 1-2% of active compounds. This small fraction in itself is a plethora of nearly 75 constituents ranging from simple minerals to complex compounds comprising of vitamins (A,C,E,B12), enzymes, minerals (Zn, Cu, Se, Ca), sugars, anthraquniones (Aloin, Aloe-emodin, Emodin, acemannan considered as the major active compounds ), fatty acids, hormones ,essential and non-essential amino acids, others such as salicylic acid, arachidonic acid, saponins and many more [20].

World literature documents in-vitro, in-vivo and clinical trials elucidating the pharmacological activities of aloe vera, owing to its anti-inflammatory, immunomodulatory, antioxidant, wound healing, antimicrobial, anti-tumour, antiseptic exhibition of properties.

Administered either in systemic form: juice, syrup, capsules or even in topical form: gel (varied concentration available), cream, mouth wash. Easy availability and cost effective are two attractive attributes of aloe vera. It has also been reported to be safe and well tolerated without any side effects in general. However, allergic reaction on topical application due to anthraquinones compounds- diarrhoea, electrolyte imbalance on ingestion has been reported.Thereby, International Aloe Committee of Science Standards has determined that the maximum allowable Aloe vera juice content for oral medical use should be less than 10 ppm [21].

Positive results have increased its acceptance into various treatment protocols. In majority, clinical trials with aloe vera are documented rather than its isolated compounds. Hence the potential and efficacy can be better elucidated with further unravelling the complexity of action and its effects.

**Spirulina**

Arthrospira, commonly referred to as Spirulina, a ubiquitous blue-green filamentous unicellular microalgae, belongs to the class of cyanobacteria. Native to tropical – sub tropical

salt lakes with high pH, Arthrospira platensis is the predominant species among the family and most often commercially cultivated [22].

Known as a functional food, it is a rich source of proteins (60-70%), amino acids, vitamins (B complex, carotenoids, tocopherols) essential oils (stearidonic Acid, arachidonic acid, γ-linolenic acid), polysaccharides, cyanins (C-phycocyanin) and minerals (iron, calcium).

The bioactivity of these compounds includes cancer prevention due to antioxidant, anti-inflammatory and antimutagenic activity, mutagen trapping, xenobiotic metabolism modulation, apoptosis induction and ability to bind to heavy metals and radioisotopes [22].

These functions have been elicited and probable mechanism been put forward independently by many in vitro and in vivo studies. The antioxidant property has been attributed to its phytopigments, tocopherol, γ-linolenic acid and phenolic compounds, mainly the carotenoids and phycocyanin.

Commonly formulated as either a single ingredient or in a combination with other algae and its compounds. They are dispensed as tablets or powders commercially. This palatable alga is non-toxic with good bioavailability as reported by studies and even recognized as safe by the Food and Drug Association [23]. However, though well tolerated, headache, muscle pain, flushing of the face, sweating, and occasionally dermatological reaction as adverse effects are recorded. Along with additional clinical studies, research on development of local and nanoparticle-based delivery approaches are needed to reinforce Spirulina in OSF treatment [23].

### Tea Pigments

Tea, (Camellia s6nensis), globally consumed beverage, is of different categories ranging from white, green, yellow, oolong, black, to dark teas. It is an ample reservoir of bioactive compounds: polyphenols, pigments, polysaccharides, alkaloids, free amino acids, saponins with a wide array of functions. Be it antioxidants, anti-inflammation, immunoregulation, anticancer function to hepato, neuro, reno, and cardiovascular protection, its benefits are many. Tea pigments, the oxidised products of polyphenols, mainly comprise of theaflavins (TFs), thearubigins (TRs), and theabrownin [24].

This polyphenol component is considered as the main antioxidant component of tea. It functions both as a direct and indirect ROS scavenger. Its antioxidant activity involves the NF-κB signalling pathway. They improve microcirculation, increase the activity of superoxide dismutase [25].

Tea and tea pigments have an exceptional set of benefits. Global availability, popular beverage, economic, safe and well tolerated, they also surpass the antioxidant capacity of vitamins and offsets the latter disadvantages of photosensitivity of natural vitamin and adverse effects of synthetic vitamin [25].

However, many challenges are met for its clinical applications, be its form, usage, dosage, regulation of bioavailability of tea and its compounds. Further studies on tea and its compounds as a treatment modality are required to establish its role in treatment of OSF.

## Vasodilators

The basis for prescribing vasodilators in OSF is capillary dilation which help to restore the nutrients and therapeutic supply to the area of interest.

### Pentoxifylline

Pentoxifylline, a methylxanthine derivative, is used to treat peripheral vascular diseases owing to its vasodilating property. It is a non-specific type IV phosphodiesterase inhibitor, with multiple biological functions. Reduction in collagen production (fibrinolytic response), IL-6, IL-2 and TGF α and β1 expression (anti-inflammatory response); upregulation of VEGF mRNA through mRNA stabilization and its half-life prolongation (vasodilation); increase in leukocyte chemotaxis, anti-thrombin, anti-

plasmin activities, red cell deformability; increase in PGE2 and PGI2 by vascular endothelium(cellular integrity and homeostasis) ;decrease in aggregation of red cells and platelets, granulocyte adhesion and fibrinogen levels are few functions documented [26].

The fibrinolytic activity by PTX is credited to increased collagenase activity and decreased collagen, glycosaminoglycans, and fibronectins production by the fibroblasts. Studies have also reported PTX inhibitory activity on IL-1 induced fibroblast proliferation and TNF-α induced fibroblast collagen and glycosaminoglycans synthesis. The drug is prescribed as capsules or sustained release tablet for oral consumption initially through lesser dose followed by recommended dose which is 400 mg three times a day after food [27].

Dose related side effects such on gastro intestinal and central nervous system on PTX administration comprising of dizziness, headache, tremor, anxiety, confusion, dyspepsia, nausea and/or vomiting, bloating and flatus. In addition, SRT may lead to minimal gastric intolerance. As contrasting results were observed with PTX in OSF, Lui et al conducted a meta-analysis and authors observed that PTX effectively improved the burning sensation and its therapeutic efficacy also increased with time [27].

### Nylidrin Hydrochloride

Nylidrin hydrochloride is a peripheral vasodilator which is chemically associated to the epinephrine-ephedrine series. In diffuse fibrosis, it is believed to act by relieving the local ischemic effect, leading to blood vessels dilation hence warranting nutritional and therapeutic measures reach site of interest. This action is considered beneficial in OSF wherein local ischemic effects secondary to local fibrous conditions; hyperkeratosis are its features. it is orally administered commonly in combination with other conventional OSF therapies. It is noted to be more effective in early onset cases and in younger age group [28].

### Isoxsuprine

Isoxsuprine, a phenylalanine derivative of epinephrine, is a β-adrenoreceptor agonist. It causes an increase in cytosolic calcium concentration level, thereby stimulating the production and release of various endothelium-derived vasodilators. Further, it also inhibits platelet aggregation and reduces blood viscosity. It is reported to cause facial flushing on low dose and tachycardia and hypotension on high dose administration. Studies have reported no adverse effects for the dosage administered. Among all the vasodilators studied, isoxsuprine was reported to be effective and well tolerated with the used dosage [29].

## Biogenic Stimulation

Biogenic stimulators are substances with capability to stimulate the biochemical and regenerative process when placed in contact with diseased tissue. Various sources considered for tissue therapy are placenta, placental extract, cod-liver oil, to name a few, are administered either as auto-transplants, homologous and heterologous transplants and injections. The readily available homologous substance, the human placenta, is on the path to revolutionise the modern medicine.

### Placental Extract

Placental extract, an immunologically privileged organ, is known to stimulate recovery of diseased tissues through biogenic stimulation. It is an assembly of assorted bioactive molecules ranging from peptides, amino acids, growth factors, glycosaminoglycans, nucleic acids, polydeoxyribonucleotides, hormones and proteins whose actions on various sites and conditions have been studied and recorded [30].

Immunotropic effect exerted on both humoral and cell mediated immunity; restoration of T and B lymphocytes dysfunction

to normal depicting immunomodulatory effect; suppression of prostaglandin synthesis and perotonin release aiding anti-inflammatory action; vascularization flow promoting wound healing, metabolism stimulation, analgesic function, enhancement of recovery and regeneration of tissue owing to the growth factors present are some on the biological functions reported. These assorted actions are considered favourable in OSF management [30].

Both topical and intra lesional injection are advocated, however clinicians did report difficulty while administering intralesionally in severe grade OSF cases. On its efficacy assessment, it was observed that though mouth opening was partially relieved, however, improvement in burning sensation was substandard.[30] On the contrary, its post operative use in OSF patients treated with fibrotomy with buccal fat pad coverage and coronoidectomy, mouth opening presented with superior results.

## Vitamins and Micronutrients

Vitamins and micronutrients are essential for the overall well-being and maintenance of health.

### Vitamins

Vitamin E also known as tocopherol, functions as a chain breaking antioxidant which inhibits propagation of free radical reaction. It is believed to harbour a preventive role in oral carcinogenesis owing to its ability to inhibit tobacco specific nitrosamine reactions. The diverse actions interpreted by vitamin E in literature are experimental carcinogenesis retardment, adequate Langerhans cells sustainment, effective humoral immune response stimulant, anti-inflammatory action and even stimulation of potent immune response to eradicate microscopic carcinoma foci [31]. Vitamin C, also known as L-ascorbic acid, is a potent anti-oxidant and immune modulating agent. It exerts multitude beneficial effects ranging from stimulation of neutrophil migration, enhancement of phagocytosis, killing of microbes, limits vitamin E degradation, constrains formation of nitrosamine, supports in absorption of iron and so on. Vitamin A, also known as retinol, possess both promotion and regulation role on the innate and adaptive immunity [32]. Vitamin B complex plays an essential role to maintain optimal health status. It is though to alleviate the clinical presentation of OSF like glossitis and cheilosis. Further, it exerts a positive influence towards wound healing [33].

### Micronutrients

Zinc, an essential micronutrient for the maintenance of good health possess anti-inflammatory, anti-oxidant function through activation of superoxide dismutase and production of metallothionein protects the cells and the DNA from damage. Additionally, it is also important for activation of numerous enzymes and proteins. It is also vital in the absorption of vitamin A, E, and folate [34]. Iron, another crucial element, participates in diverse metabolic processes , including oxygen transport particularly haemoglobin and myoglobin, deoxyribonucleic acid (DNA) synthesis, respiratory and oxidative metabolism, electron transport and an essential component for various enzymes [35]. Commonly dispensed as oral supplements in the form of tablets, capsule, chewable tablets or even as injections either as an individual vitamin or multivitamins with or without the micronutrient supplement are available commercially.

## Novel Therapies

### Oxitard

Oxitard, a phytopharmaceutical formulation, with a protective action. The capsules of oxitard are a combination of 1. Extracts: Mangifera indica (antibiotic, anti-asthamatic, antiseptic, antiviral, hypotensive, anti-emetic), Withania somnifera (anti-stress, anti-anxiety, anti-

inflammatory, anti-convulsive and anti-arthritic properties), Daucus carota (antiseptic), Glycyrrhiza glabra (immunomodulatory and anti-inflammatory, normalizes the hoarseness in voice ), Vitis vinifera (anti-inflammatory, astringent and an effect to curb the burning sensation); 2. Powders: Emblica officinalis (vitamin C and is a potent antibiotic) and Yashada bhasma (protein synthesis, cell division and wound healing); 3. Oils: Triticum sativum (minerals and has an antioxidant property) [36].

It is an antioxidant, gastro and cardio protective with adaptogenic and immunomodulatory in function. Its ability to neutralises oxidation reaction and its products provides cellular protection.

The formulation is dispensed in capsules, advised oral administration of 2 capsules twice daily. Though oxitard was well tolerated, studies have reported mild gastrointestinal discomfort for a short duration in patients. Further studies are required to evaluate the mechanism of action and its efficacy in the treatment of OSF

**Garlic**

Garlic (Allium sativum), traditionally used allium vegetable, known for its nutritional and medicinal values, is consumed worldwide. Allicin, an organosulphur functional compound in garlic is one among the most investigated component. It is known to be associated with anticancer, anti-inflammatory, antimicrobial, immune modulatory, antifibrotic, cardio-protective functions and even modulate cholesterol levels to name a few.

Studies have reported its anti-cancer role by its ability to target cells in G0/G1 phase and induce G2/M phase arrest in Oesophageal Squamous cell carcinoma cases. Reports also suggest that allicin treatment was able to reinstate cell surface glycoconjugates as observed in DMBA altered plasma glycoconjugates and tumours of buccal mucosa [37].

The pharmaceutical forms available are tablets, capsules, powder, aged extract, injections while to date intralesional injection of allicin is reported for OSF. The significant adverse effect reported is its characteristic breath odour.

Though scientific evidence exists about the beneficial aspects of garlic and its derivates, yet limited studies are documented irrespective of it being reported safe with few side effects and high tolerance. Lack of studies on bioavailability, pharmacokinetics and toxicology on garlic and its compounds are evident. Further, emphasis on clinical trials with these functional compounds to evaluate their efficacy and interconnection with the disease of interest are required [37].

**Colchine**

Colchine, an alkaloid, is an established antifibrotic agent, used for reducing fibrosis in liver and kidney diseases. It ensues inhibition of collagen synthesis by inhibiting procollagen secretion and its conversion to collagen. It further disrupts microtubule formation and its polymerisation. Additionally, by destabilizing microtubules, diminishing number of TNF-α receptors on macrophages and endothelial cells, inhibiting ROS production, affect chemotaxis and adhesiveness of leukocytes, affect PGE secretion and hinders inflammatory mediators release by preventing mast cell degranulation thereby exerting anti-inflammatory function. However, limited studies have been reported its use in OSF.

On oral administration of 0.5 mg colchine, no adverse effects were reported. Studies also suggest combination therapy with other drugs would be more effective, leads to reduced dosage with better outcomes [38].

**Interferon Gamma**

Interferon gamma, a cytokine is known to inhibit collagen synthesis. It basically inhibits transcription for type I and II collagen synthesis by fibroblast and myofibroblasts. This

biological action may have a significant therapeutic effect on OSF. Haque et al demonstrated in vitro inhibition of arecoline induced collagen synthesis by INF-γ in a dose related manner. They also observed in vivo improvement in the mouth opening of OSF patients with post treatment of 30±8 mm 6 months reading in comparison to 21±7 mm pre-treatment values. Further, comparatively decreased amount of inflammatory cell infiltrate was noted post intervention lesional tissue. As INF-γ were able to inhibit collagen synthesis in vivo, further studies are required to evaluate its applications and therapeutic potential in the treatment of OSF [39].

### Valdecoxib

Valdecoxib, a novel selective cyclooxygenase-2 inhibitor has shown to be beneficial in treating premalignant disease. Averineni et al developed a sustained release mucoadhesive buccal film of valdecoxib made of chitosan and hydroxypropyl methylcellulose for local action. They concluded that they were able to produce comfortable, non-irritant, self-administrable films that delivered the required therapeutic dose at the area of interest. These films overcame the short residence time of oral gels, flexibility and comfort of adhesive tablets [40].

Many other drugs such as the anti-TGF β agents, copper chelators, borneol, Danuxan Koukunga, Saliva miltiorrhiza are studied and proposed for the treatment of OSF. However, further exploration of studies on their mechanism of action, bioavailability, dosage, safety profile through larger clinical trials is required.

## Combination Therapy and Adjuvant Therapy of OSF

This comprehensive data on the different drugs available, the number of clinical trials conducted, the combination of drugs explored are extensive for the medical management of OSF. However, a striking feature to be noted is that studies did consider two principal drugs that differed in their primary mechanism of action, were administered thereby a combination therapy was followed. For example: steroids + hyaluronidase. On the other hand, some studies considered adjuvant therapy wherein treatment in addition to the primary protocol was also considered. For example: antioxidants, vitamins and micronutrients in combination with steroids. The added advantage noted of such therapy are

1. Better efficacy
2. Reduced dosage required
3. Reduced visits
4. Persistent treatment with adjuvants when compared to the weekly dosage of principal drug
5. Economic feasibility

## Future Directions

Prevention of progression, thwarting malignancy development and avoidance of recurrence are the prime principles in the management of OSF. Future directions should aim for a better cognizance of the contemporary dugs and development of targeted drug delivery system which are patient friendly and economically feasible. Moreover, the scientific research community is on a constant exploration for newer effective drugs for the treatment of OSF analysing at the different levels in the pathogenesis of OSF.

## Conclusion

Various surgical modalities though proposed, medical management forms an inseparable part of OSF management. Irrespective of numerous limitations among the different treatment regimens that are evaluated, vigorous clinical research is a prerequisite to address those shortcomings. Clinicians' treatment plan should be governed by numerous factors comprising the subjective symptoms to objective signs; to choose from the evidence-based interventions. Additionally, education intervention with reference to the habit

cessation and dietary counselling are indispensable aspects for which the patients are required to be counselled.

## Conflict of Interest

None.

## Ethical Approval

Not applicable.

## Data Availability

Not applicable.

## Authors Contribution

Dr Vidya Gurram Shankar - writing - original draft, editing and review.

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# Railway Infrastructure Development and Regional Economic Integration in Africa: Progress, Challenges and Future Prospects

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***Abstract*** *Regional economic integration remains a critical priority for Africa as the continent seeks to expand intra-African trade, strengthen regional value chains, and achieve sustainable economic development. Despite significant progress in policy initiatives such as the African Continental Free Trade Area (AfCFTA) and the Programme for Infrastructure Development in Africa (PIDA), inadequate transport infrastructure continues to restrict economic cooperation and market integration. Among transport modes, railway infrastructure offers considerable potential to reduce trade costs, improve connectivity, and facilitate the movement of goods and people across borders. This review explores the evolution of railway infrastructure development in Africa and its contribution to regional economic integration. Inferring on evidence from historical analyses, empirical studies, policy reports, and corridor-based case studies, the review explores the transformation of African railways from colonial-era extraction networks to contemporary infrastructure investments aimed at supporting regional development. Findings indicate that railway connectivity contributes positively to trade expansion, foreign direct investment attraction, market access, and cross-border economic cooperation. Major railway corridors, including the Lobito, Maputo, and emerging transcontinental corridors, demonstrate the capacity of rail infrastructure to stimulate regional integration through improved logistics efficiency and value chain development. However, the realization of these benefits remains constrained by infrastructure deficits, inadequate financing, fragmented technical standards, governance challenges, and limited technology adoption. The review concludes that railway infrastructure development is an essential enabler of Africa's integration agenda and that coordinated regional planning, infrastructure modernization, policy harmonization, and sustained investment are necessary to maximize its economic and developmental impacts. Strengthening railway networks will be critical to unlocking the full potential of AfCFTA and fostering a more interconnected and competitive African economy.*

***Keywords*** *Africa, Development, Infrastructure, Railway, Regional.*

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## Introduction

Africa's quest for regional economic integration represents one of the most significant development challenges and opportunities of the 21st century [1]. Despite comprising 54 countries with abundant natural resources and a rapidly growing population, the continent remains characterized by fragmented markets and limited intra-regional trade. Intra-African trade consistently averages between 12-15% of total continental trade [2], substantially lower than comparable figures in other regions. This limited regional integration perpetuates economic vulnerabilities, constrains industrial development, and undermines the continent's potential to leverage collective bargaining power in global markets.

The persistence of low intra-African trade stems from multiple interconnected factors, including tariff and non-tariff barriers, weak institutional frameworks, limited financial integration, and most critically, inadequate physical infrastructure. Among infrastructure deficits, transportation networks – particularly railway systems – represent perhaps the most significant constraint to regional economic integration [3]. Railways offer unique advantages for continental integration, including cost-effective long-distance freight transport, reduced environmental impact compared to road transport, and the capacity to handle bulk commodities that form the backbone of many African economies [4].

Historically, Africa's railway development followed colonial patterns designed primarily to extract raw materials from interior regions to coastal ports for export to metropolitan countries, rather than to facilitate intra-African connectivity. This legacy has resulted in fragmented railway networks characterized by different gauge systems, limited cross-border connections, and inadequate maintenance that has left many systems operating well below capacity [5]. The colonial-era infrastructure was never designed to support the vision of an integrated African economy, creating path dependencies that continue to constrain regional trade and economic cooperation.

Contemporary efforts to address these infrastructure deficits have gained momentum through various continental and regional initiatives. The African Union's Agenda 2063 envisions a transformed continent with world-class infrastructure, while the Programme for Infrastructure Development in Africa (PIDA) has identified priority railway corridors for development. Most significantly, the African Continental Free Trade Area (AfCFTA), which became operational in 2021, represents the world's largest free trade area by country participation since the formation of the World Trade Organization [6]. However, the realization of AfCFTA's potential depends critically on complementary investments in transport infrastructure that can reduce trade costs and improve market access.

Recent developments in railway infrastructure, including Chinese Belt and Road Initiative investments, regional development bank financing, and public-private partnerships, have created new opportunities for transforming Africa's transport landscape [7, 8]. Projects such as the Standard Gauge Railway in East Africa, proposed transcontinental corridors, and railway rehabilitation programs across various regions signal renewed recognition of railways' strategic importance for economic integration.

Despite growing policy attention and investment commitments, significant knowledge gaps remain regarding the relationship between railway infrastructure development and regional economic integration in Africa. While substantial literature exists on infrastructure and economic growth generally [9], comprehensive analysis specifically examining railways' role in facilitating intra-African trade, promoting industrial development, and supporting regional value chain formation remains

limited. Furthermore, existing studies often focus on individual countries or projects rather than adopting a continental perspective that considers network effects and regional spillovers.

This narrative review addresses these knowledge gaps by providing a comprehensive examination of railway infrastructure development and its relationship with regional economic integration across Africa. The review synthesizes existing evidence on railway investments, trade facilitation mechanisms, and economic outcomes while identifying key challenges and opportunities for future development.

## Evolution of Railway Infrastructure in Africa

The evolution of railway infrastructure in Africa represents a complex narrative spanning over 150 years, characterized by distinct phases of development, decline, and recent renaissance that reflects broader patterns of colonial exploitation, post-independence policy shifts, and contemporary globalization dynamics. African railway development began in 1862 with the Cape Town-Wellington Railway in South Africa, marking the continent's entry into the railway age [10]. The colonial period witnessed rapid expansion following the Berlin Conference and the scramble for Africa, with lines opening in Mozambique in 1890, Burkina Faso in 1892, and Senegal in 1894, such that by 1904, the median country in sub-Saharan Africa had established railway infrastructure [10].

The most comprehensive quantitative analysis of this development confirms that railroads were fundamentally a colonial transportation technology, with 74% of today's 66,000 km network built by 1929, 88% by 1960, and 96% by 1975 [10]. Colonial powers constructed railways primarily for military domination and trade facilitation, with rail transport being dramatically cheaper than alternatives – roughly 10 times cheaper than headloading in Ghana circa 1914 and 100 times cheaper in Kenya in 1902 [10]. The construction of railways was governed by multiple factors, including port access, natural resource exploitation, territorial control, and administrative requirements, as evidenced in West African development, where the first Dakar-St Louis line was constructed in 1885 [11].

The post-independence period marked a fundamental shift in transportation priorities, with paved roads emerging as the preferred post-colonial technology while railway investment declined significantly [10]. This transition reflected changing economic priorities and the perceived advantages of road transport for newly independent nations, leading to systematic underinvestment in railway infrastructure that persists today. Most sub-Saharan African networks outside South Africa continue to operate to standards established during their original construction, with limited rehabilitation over decades [12].

Contemporary railway infrastructure in Africa suffers from multiple interconnected challenges that have been systematically documented through comprehensive research. A systematic literature review of 49 peer-reviewed papers published between 2000 – 2022 identified low penetration of electric-powered trains, limited technology integration, and inadequate shuttle services as persistent challenges, while revealing significant knowledge gaps in passenger demand optimization, price optimization, route scheduling, and transport emission experimentation [13]. Most railway systems in southern Africa are not functioning optimally due to historic underinvestment, creating an infrastructure gap that hinders economic development and regional integration, with additional challenges posed by gauge interoperability issues between Standard Gauge and Cape Gauge systems [5].

The current state of West African railways exemplifies broader continental challenges,

with deteriorated infrastructure, obsolete technologies, and low-quality operations resulting in traffic density below 1 million traffic units per route-km in most countries except Guinea, where private mining companies utilize railway lines extensively [11]. The 1990s marked a significant institutional shift with railway concessioning and privatization initiatives designed to encourage commercialization and reduce government financial burden [12]. However, analysis of railway privatization results across thirteen African concessions reveals mixed outcomes, with some improvements in operational efficiency offset by continued struggles with inadequate investment in infrastructure rehabilitation and modernization [14].

The 21st century has witnessed a significant railway renaissance driven primarily by Chinese investment through the Belt and Road Initiative, building upon the foundation established by the landmark Tanzania-Zambia Railway Project constructed between 1968-1976 with a Yuan 988 million interest-free loan [15]. Contemporary Chinese involvement in African railway development has been comprehensively analyzed, revealing how infrastructure projects serve Chinese capital expansion while potentially perpetuating Africa's dependent integration into global capitalist systems [16]. The analysis of Kenya's Standard Gauge Railway project under the Belt and Road Initiative identifies potential economic benefits including socio-economic development, government revenue generation, and enhanced regional integration, while highlighting concerns about debt burden and the need for more transparent stakeholder engagement [8].

The examination of railway imperialisms in East Africa reveals China's transition from providing anti-imperial infrastructure through projects like the Tanzania-Zambia Railway Authority to becoming a neo-imperial investor through contemporary Belt and Road Initiative projects [17]. This transformation reflects broader patterns in which recent rail infrastructure projects are often driven by international suppliers' preferences rather than creating railways that match regional network requirements, suggesting a disconnect between project design and regional integration objectives [18].

## Railway Infrastructure and Regional Economic Integration

Railway infrastructure development represents a critical catalyst for regional economic integration across Africa, serving as both a facilitator of trade expansion and a driver of sustainable economic growth that has gained increasing attention as the continent pursues deeper economic integration through initiatives such as the African Continental Free Trade Area (AfCFTA) and various regional economic communities. The relationship between transport infrastructure and trade facilitation in Africa is well-established in empirical literature, with research examining the ECOWAS region demonstrating that including a rail connection between trading partners results in an average trade increase of 3.5 percent [19]. This finding underscores the tangible benefits that railway connectivity can deliver to regional trade volumes, while analysis of Eastern African countries reveals that transport infrastructure, including railways, has significant and positive effects on trade, with infrastructure exerting "a strong effect on trade and growth" in the region [7].

The broader transport infrastructure landscape in Africa shows consistent positive impacts on economic performance, as studies of Kenya, Tanzania, and Uganda found that transport infrastructure positively drives long-term growth, with cross-border trade volumes significantly boosting economic development in Kenya and Uganda [20]. These findings align with broader African infrastructure research showing that infrastructure contributed 99 basis points to per capita

economic growth across the continent, with most of the contribution coming from increases in stocks rather than quality improvements [21]. The impact of railway infrastructure on economic integration varies significantly across African regions, reflecting different levels of development, policy frameworks, and existing infrastructure stocks, as evidenced in the Southern African Development Community (SADC) where empirical analysis reveals a positive and statistically significant relationship between infrastructure development and intra-regional trade, with infrastructure improvements increasing intra-SADC exports by 1.76 percent [2].

The growth effects of infrastructure investment are particularly pronounced in less developed African economies, with research indicating that infrastructure spending and increments in access to infrastructure influence economic growth more significantly in lesser developed economies than in relatively more developed ones [22]. This suggests that railway infrastructure investments may deliver higher returns in countries with existing infrastructure deficits, making strategic targeting of investments crucial for maximizing regional integration benefits. Railway infrastructure facilitates regional economic integration through multiple channels beyond direct trade cost reduction, as infrastructure development creates spillover effects across neighboring countries where improved connectivity in one nation raises the profitability of investment in neighboring countries by creating wider markets and improving export opportunities [23]. This interconnectedness suggests that railway projects designed with regional integration in mind can generate benefits that extend far beyond national borders, particularly evident in the interaction between infrastructure and other economic factors, where research shows that the interaction between trade openness and infrastructure leads to increased foreign direct investment inflows, which in turn have positive and significant effects on growth [24].

## Major Railway Corridors Supporting Integration

Africa's railway corridors have emerged as critical infrastructure for fostering regional economic integration, with several major corridors demonstrating significant impacts on trade flows, investment patterns, and cross-border economic cooperation. The continental recognition of this potential is evident in the Program for Infrastructure Development in Africa (PIDA), which has identified 42 corridors as forming a core network for regional integration and global connectivity [25].

The Lobito Corridor represents one of the most promising examples of railway infrastructure driving regional integration in Southern Africa. Connecting Angola, the Democratic Republic of Congo, and Zambia, this corridor has demonstrated measurable impacts on economic integration through multiple channels. Research using structural gravity modeling has shown that the corridor's infrastructural capacity, ability to anchor critical value chains, and regional integration functions all positively impact export volumes moved through the corridor [26]. The corridor's development leverages Southern Africa's transport infrastructure to drive economic transformation through agriculture and mining value chains while facilitating stronger bilateral and multilateral relations among participating countries.

The integration effects of railway corridors extend beyond direct trade facilitation to encompass broader investment patterns across regions. Spatial econometric analysis covering 40 sub-Saharan African countries over the period 2000-2021 reveals that shared rail corridors create spillover effects, where the presence of railway infrastructure in one country increases inward foreign direct investment not only domestically but also in

neighboring countries [27]. This finding suggests that railway corridors function as regional integration catalysts, creating investment clusters that transcend national boundaries and foster economic interdependence among participating nations.

The Maputo Corridor provides valuable insights into the conditions necessary for successful railway corridor development and integration outcomes. This corridor's experience demonstrates that effective integration requires a combination of public and private investments to improve infrastructure, an institutional framework promoting coordination, focus on operational efficiency of logistics services, and proven economic potential [25]. The corridor's success in enabling trade and economic development illustrates how railway infrastructure can serve as a foundation for broader regional economic integration when supported by appropriate institutional arrangements.

Continental-scale railway initiatives further demonstrate the integration potential of rail infrastructure. The Tripoli-Windhoek corridor, incorporating road-rail bridge projects, has shown positive and significant effects on exports from participating countries over the 1980-2020 period [28]. This transcontinental approach to railway development represents an ambitious vision for African integration, connecting diverse economic regions and facilitating north-south trade flows that complement traditional coastal-inland corridor patterns.

The integration mechanisms through which railway corridors operate are multifaceted and interconnected. Railway infrastructure reduces transportation costs, which is particularly crucial for landlocked nations that constitute a significant portion of African countries [29]. By providing cost-effective solutions for least developed countries, railway corridors enable these nations to participate more effectively in regional and global value chains. The corridors also facilitate the development of special economic zones and support the establishment of regional trade agreements, creating institutional frameworks that reinforce the physical infrastructure investments [26].

## Infrastructure Deficits and Technical Barriers

Africa's railway infrastructure faces primary deficits that severely constrain the benefits of economic integration. Parida (2013) identifies an infrastructure gap resulting from historical underinvestment, noting that most railway systems in southern Africa are not functioning as they should [5]. This underinvestment has created a continent-wide challenge where Mbekeani (2010) observes that inadequate infrastructure and poor transport organization make it difficult to guarantee the timely delivery of goods or ensure reliability or flexibility in the supply of goods [30].

Technical standardization presents another critical barrier to regional connectivity. Parida (2013) again highlights the gauge and interoperability issue, i.e., Standard Gauge vs Cape Gauge, as a strategic challenge, particularly regarding requirements for interconnections with other regional railways. This fragmentation prevents seamless cross-border rail operations, which are essential for economic integration [5].

The adoption of modern technology remains limited across African railway systems. Bouraima et al. (2023) documented low penetration of electric-powered trains, technology integration, and shuttle services in their systematic review of 49 railway studies. These technological gaps compound existing infrastructure deficits, limiting the efficiency gains necessary to compete with other transport modes and realize integration benefits [13].

## Future Prospects for Railway Development and Regional Economic Integration in Africa

The future of railway development in Africa is increasingly being shaped by continental and regional frameworks that recognize transport infrastructure as a catalyst for economic transformation and regional integration. As African economies seek to deepen trade relationships, strengthen regional value chains, and facilitate the implementation of the African Continental Free Trade Area (AfCFTA), railway systems are emerging as strategic assets capable of addressing long-standing transportation bottlenecks. In recognition of this potential, the African Union (AU) has placed railway development at the centre of its Agenda 2063 vision through the African Integrated High-Speed Railway Network (AIHSRN), a flagship initiative designed to connect major African capitals, commercial centres, and industrial hubs through interoperable rail corridors [31]. The overarching objective is to facilitate seamless movement of people and goods across national boundaries, thereby enhancing continental competitiveness and fostering sustainable economic growth.

The continental railway agenda is reinforced by several regional infrastructure programmes, including the Programme for Infrastructure Development in Africa (PIDA) and the Southern African Development Community (SADC) Regional Infrastructure Development Master Plan. These initiatives emphasize the importance of coordinated transport investments capable of overcoming the fragmented nature of Africa's existing railway systems while promoting greater connectivity between countries and regions [5]. Similarly, regional economic blocs such as the Economic Community of West African States (ECOWAS) have developed strategies aimed at creating efficient and interoperable railway systems that can support trade expansion, regional mobility, and economic cooperation across West Africa [11]. Collectively, these frameworks reflect a growing consensus that railway infrastructure will play a fundamental role in achieving the continent's integration aspirations.

Evidence of this commitment is increasingly visible through major railway investments currently being undertaken across the continent. In West Africa, Ghana has embarked on an ambitious Railway Master Plan that seeks to rehabilitate, modernize, and expand existing railway infrastructure while extending connectivity to neighboring countries such as Côte d'Ivoire, Togo, and Burkina Faso. The programme is structured into six implementation phases and represents one of the most comprehensive railway development strategies in the region, encompassing both infrastructure upgrades and rolling stock acquisition [11]. Beyond improving domestic mobility, these cross-border connections are expected to strengthen regional trade networks and facilitate access to seaports for landlocked economies.

Nigeria has similarly emerged as a major player in Africa's railway renaissance. Significant investments have been directed towards modernizing the country's rail network by developing standard-gauge railway corridors. Notable projects include the Abuja–Kaduna railway, the Lagos–Ibadan railway, and the broader rehabilitation of the western railway corridor linking Lagos to Kano. Additionally, the proposed Lagos–Calabar Coastal Railway represents one of the largest railway infrastructure projects currently under development on the continent. Beyond their national significance, these projects are expected to enhance regional connectivity by linking major commercial centers and facilitating trade flows between Nigeria and neighboring countries. The Kano–Maradi railway extension to Niger Republic further demonstrates the growing emphasis on cross-border rail infrastructure as a mechanism for

strengthening regional integration and economic cooperation within the ECOWAS sub-region [11].

Similar trends can be observed elsewhere across Africa. East African countries continue to invest heavily in standard-gauge railway projects to improve regional connectivity, while Southern African nations prioritize railway corridor development to support mineral exports, industrialization, and trade facilitation. These developments indicate a broader continental shift towards recognizing rail transport as a strategic component of economic development planning rather than merely a transport service.

The importance of railway development for regional integration extends beyond physical connectivity. Modern railway networks have the potential to transform Africa's economic geography by reducing transportation costs, increasing market accessibility, and improving the efficiency of supply chains. The vision underpinning many regional railway initiatives is the creation of an integrated economic space characterized by the free movement of goods, services, capital, and people. Improved railway connectivity is expected to support industrial development by linking production centres with domestic and international markets while simultaneously enhancing access to employment opportunities and social services [11].

Railways are also particularly important for facilitating the exploitation and commercialization of Africa's abundant natural resources. Historically, railway systems across the continent have been developed primarily to connect ports with mining regions and major urban centres. This pattern remains relevant today, especially considering that approximately 90% of Africa's international trade by volume is transported by sea [18]. Efficient rail links between inland production zones and maritime gateways can therefore significantly enhance export competitiveness and reduce logistics costs. Furthermore, growing partnerships between African countries and international development partners, particularly China, have accelerated the implementation of railway projects across the continent. Building upon the legacy of the Tanzania-Zambia Railway (TAZARA), contemporary China-Africa cooperation has contributed substantially to the financing and construction of strategic railway infrastructure, creating opportunities for greater regional connectivity and economic integration [15]. These initiatives increasingly complement broader regional development programmes and may contribute to the realization of continental integration objectives when effectively coordinated [32].

The growing interest in railway transport is also supported by its comparative advantages over other transport modes. Although road transport currently dominates African transportation systems, accounting for approximately 90% of passenger movements and 80% of freight transport, railways offer several economic and environmental benefits that make them particularly attractive for long-distance and bulk transportation [18]. Studies indicate that rail freight can generate between 75% and 85% fewer greenhouse gas emissions per transport unit compared with heavy-duty road vehicles. Additionally, the external costs associated with rail transport – including environmental impacts, congestion, accidents, and infrastructure wear – are substantially lower than those associated with road transportation. Estimates suggest that rail transport can reduce external costs by approximately 47.5% per passenger-kilometre and 75.4% per tonne-kilometre relative to road-based alternatives [18]. These advantages are particularly relevant as African countries seek to balance economic growth with environmental sustainability and climate resilience objectives.

Despite these promising developments, several challenges continue to constrain the realization of Africa's railway ambitions. A

major concern is the deteriorated condition of much of the continent's railway infrastructure. Decades of underinvestment, inadequate maintenance, and limited technological modernization have resulted in extensive sections of railway networks becoming inefficient or non-operational. Many systems continue to rely on outdated technologies, fragmented information systems, and operational practices that fall below international standards for safety and performance [11, 18].

Interoperability remains another critical obstacle. African railway networks operate using multiple track gauges, ranging from narrow-gauge systems to standard-gauge infrastructure. This diversity limits seamless cross-border operations and increases operational complexity. Differences in signalling technologies, communication systems, and technical standards further complicate efforts to establish integrated regional railway networks. In some instances, locomotives operating across multiple jurisdictions require different train control systems, thereby increasing operational costs and reducing efficiency [31].

Institutional and governance challenges also persist. The implementation of regional railway projects is often complicated by competing national priorities, fragmented regulatory frameworks, and insufficient coordination among participating countries. Bilateral infrastructure agreements occasionally result in isolated railway projects that are poorly integrated into broader regional transport strategies. Consequently, policy inconsistencies and regulatory barriers continue to hinder the development of efficient cross-border railway systems [11, 33].

Addressing these challenges will require coordinated and sustained interventions at both national and continental levels. One of the most frequently proposed solutions is the harmonization of technical standards across Africa's railway sector. The African Union and regional economic communities have important roles to play in promoting the adoption of common railway specifications, including standard track gauges, signalling technologies, electrification systems, and operational protocols. Standardization would improve interoperability, reduce maintenance costs, and facilitate the creation of truly integrated continental railway networks [31].

Capacity development is equally important for ensuring the long-term sustainability of railway investments. Strengthening local expertise through specialized railway education programmes, regional training centres, and knowledge-sharing initiatives can help address existing skills gaps while reducing dependence on foreign technical expertise. The establishment of regional railway academies and research centres may further contribute to workforce development and innovation within the sector [11].

Looking ahead, the development of a comprehensive continental railway strategy that integrates infrastructure planning, interoperability standards, safety management, data governance, and investment priorities will be essential. Such a strategy should be complemented by proactive regional implementation mechanisms, including standard-gauge railway expansion programmes, railway technology transfer initiatives, and collaborative financing arrangements. Emerging digital technologies, predictive maintenance systems, intelligent signalling platforms, and data-driven railway management solutions also offer significant opportunities to improve operational efficiency and network reliability [18].

Ultimately, the success of Africa’s railway transformation agenda will depend on the ability of governments, regional organizations, development partners, and private investors to align their efforts around a shared vision of continental integration. If effectively implemented, future railway corridors have the potential to reshape trade patterns, strengthen

regional value chains, reduce transport costs, and support the broader objectives of sustainable economic development across Africa.

## Conclusion

Railway infrastructure plays an essential role in alleviating regional economic integration in Africa by improving trade connectivity, reducing transport costs, attracting investment, and supporting regional value chains. Evidence from major railway corridors shows that enhanced rail networks can facilitate significant economic spillovers beyond national borders. Nevertheless, persistent infrastructure deficits, interoperability challenges, financing constraints, and institutional weaknesses continue to limit the full realization of integration benefits. To support the objectives of AfCFTA and broader continental development agendas, African countries must prioritize coordinated railway planning, modernization of existing networks, harmonization of technical standards, and sustainable investment strategies. A more connected railway system is indispensable for achieving deeper regional integration and long-term economic transformation across the continent.

## Conflicts of Interest

The authors declare that they have no conflicts of interest

## Ethical Approval

Ethical Approval does not apply to this paper.

## Data Availability

Not Applicable

## Author Contributions

Afolabi O. M. conceptualized this study, Zirra J.F. critically revised and corrected the manuscript for important intellectual content, and supervised the study. Afolabi O.M. conceived and drafted the review outline and contributed to manuscript writing. Afolabi O.M. and Zirra J.F. participated in the literature review and contributed significantly to the writing and revision of the manuscript. All authors read and approved the final version of the manuscript.

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# The Role of Soft Skills and Short Courses in Enhancing Career Improvement and Job Readiness among University Graduates in Somaliland

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***Abstract*** *The transition from university to employment remains a critical challenge for graduates in developing nations, particularly in post-conflict contexts such as Somaliland. While technical competencies are emphasised in higher education, soft skills development and participation in short professional courses are often neglected. This study investigated the role of soft skills and short courses in enhancing career improvement and job readiness among graduates from three universities in Hargeisa, Somaliland. A descriptive research design with a mixed-methods approach was employed. A sample of 150 graduates (50 from each university) from the Class of 2025 was selected using convenience sampling. Data were collected through a structured questionnaire and semi-structured interviews and analysed using SPSS version 26. Graduates demonstrated low overall soft skills ($M = 2.28$ on a 5-point scale), with leadership ($M = 1.95$) and critical thinking ($M = 2.08$) the lowest. A significant positive correlation was found between soft skills and job readiness ($r = 0.682$, $p < 0.01$). While 36.7% had not attended short courses, participants reported better employment outcomes (44.2% vs. 16.4%). A moderate positive correlation was found between short course participation and career improvement ($r = 0.548$, $p < 0.01$). The majority (68.0%) were unemployed, with 78.7% attributing this to insufficient soft skills. Soft skills and short courses significantly enhance graduate employability. Higher education institutions must integrate soft skills training into curricula, and coordinated interventions are needed to address the employability crisis.*

***Keywords*** *Career Improvement, Graduate Employability, Job Readiness, Short Courses, Soft Skills, Somaliland.*

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## Introduction

The relationship between higher education and employment outcomes has attracted sustained scholarly attention over the past two decades, with particular emphasis on the role of non-technical competencies in shaping graduate trajectories in the labour market. As economies become increasingly knowledge-driven and technologically sophisticated, the attributes that distinguish successful professionals extend far beyond disciplinary expertise to encompass interpersonal effectiveness, adaptive capacity, and continuous learning orientation [1, 2]. These attributes, broadly classified as soft skills, have emerged as critical determinants of employability across diverse industrial and geographical contexts.

In the Horn of Africa, where post-conflict reconstruction has catalysed rapid expansion of higher education institutions, the employability of university graduates presents a particularly urgent policy and research concern. Somaliland, which declared independence from Somalia in 1991 and has since developed a functioning governmental and educational infrastructure, has witnessed significant growth in its higher education sector. Institutions such as Golis University, New Generation University, and Admas University now collectively produce thousands of graduates annually, yet youth unemployment remains disproportionately high, with estimates exceeding 60% [3]. This paradox of educational expansion alongside persistent graduate unemployment demands careful empirical investigation.

Existing evidence from employer surveys in Hargeisa indicates that a substantial proportion of graduates, while technically qualified in their respective fields, demonstrate significant deficiencies in communication, teamwork, problem-solving, and professional conduct [4]. These observations align with broader patterns documented across Sub-Saharan Africa, where the disconnect between university curricula and labour market requirements has been identified as a structural barrier to graduate employment [5, 6]. Concurrently, short professional courses, which offer targeted instruction in employability-related competencies, represent a potentially valuable but underutilised resource for addressing these skills gaps.

Despite the apparent importance of soft skills and professional development opportunities for graduate employability, empirical research examining these issues within the specific context of Somaliland remains limited. The present study addresses this gap by investigating the levels of soft skills possessed by graduates from three major universities in Hargeisa, examining their participation in short courses, and assessing the relationships between these variables and their job readiness and career improvement. The study is guided by the following research questions:

1. What is the level of soft skills possessed by graduates from Golis University, New Generation University, and Admas University?
2. What types of short courses have the graduates attended?
3. What is the relationship between soft skills and job readiness among the graduates?
4. What is the relationship between short courses and career improvement among the graduates?
5. What challenges do graduates face in the job market due to lack of soft skills?

## Literature Review

### Soft Skills and Graduate Employability

The concept of soft skills, while lacking a universally accepted definition, is generally understood as encompassing the constellation of personal attributes, interpersonal competencies, and behavioural tendencies that enable individuals to interact effectively with others and navigate complex social and

professional environments [1]. Schulz [7] characterises soft skills as the integration of personality traits, social graces, communication abilities, language proficiencies, and personal habits that collectively define an individual's capacity for relational engagement. Unlike hard skills, which are typically job-specific, measurable, and amenable to formal instruction, soft skills are more diffuse, contextually variable, and developed through experiential learning, practice, and reflective engagement [8].

The significance of soft skills for employment outcomes has been documented across diverse national and sectoral contexts. Andrews and Higson [9], in a European study of graduate employability, found that employers consistently valued communication, teamwork, and problem-solving abilities above technical knowledge when evaluating candidates. Similarly, the National Association of Colleges and Employers [10] annual employer survey in the United States has repeatedly identified communication skills, critical thinking, and teamwork as the most sought-after attributes in new graduates. The World Economic Forum's Future of Jobs Report [2] further reinforces this trend, identifying analytical thinking, creativity, resilience, and emotional intelligence among the fastest-growing skill demands across industries globally.

In developing country contexts, the soft skills deficit among graduates assumes particular significance. Hassan et al. [11] found in their Malaysian study that graduates with well-developed communication, teamwork, and leadership competencies enjoyed superior employment prospects and accelerated career advancement. Mahmud et al. [12], examining generic skills among Bangladeshi university students, reported widespread inadequacies in communication, problem-solving, and leadership, prompting recommendations for curriculum-integrated skills development. More recently, the British Council [5], in a comprehensive study of graduate employability across Sub-Saharan Africa, identified soft skills deficiencies as a primary barrier to graduate employment, with consistent gaps in communication, teamwork, and critical thinking reported across multiple countries.

**Short Courses and Professional Development**

Short courses, also termed professional development programmes, continuing education offerings, or vocational training modules, constitute condensed educational experiences designed to impart specific competencies within abbreviated timeframes [13]. Ranging from several days to several months in duration, these programmes focus on practical, immediately applicable skills rather than broad theoretical foundations. Their proliferation has been driven by accelerating technological change, the imperative for workforce upskilling, and increasing demand for flexible learning modalities [14].

The effectiveness of short courses in enhancing employment outcomes has received empirical support. Finch et al. [15], investigating work-integrated learning and professional development in Australia, found that graduates who participated in short courses and related programmes demonstrated higher job readiness and were more likely to secure employment within six months of graduation. Singh and Singh [16] reported that Indian students who received soft skills training through workshops exhibited significantly improved communication abilities and interview performance. A meta-analysis by Blunch and Castro [17] found positive effects of vocational training, including short courses, on employment outcomes for young people, although the magnitude of impact varied according to programme relevance and quality.

### Theoretical Framework

This study draws upon three interrelated theoretical perspectives. Human Capital Theory, developed by Becker [18] and Schultz [19], posits that investments in education, training, and skill development yield economic returns through enhanced productivity and employability. Soft skills represent a form of general human capital, valued across industries and transferable between contexts. Social Learning Theory, articulated by Bandura [20], emphasises the role of observation, modelling, and experiential practice in skill acquisition, providing a theoretical basis for understanding how short courses facilitate competency development through interactive and practical learning approaches. Career Development Theory, as conceptualised by Super [21], frames the school-to-work transition as a critical developmental stage in which the integration of self-concept with occupational roles determines employment success, with soft skills and professional development serving as enabling resources for this transition.

## Materials and Methods

### Research Design and Approach

This study employed a descriptive research design with a mixed-methods approach. The descriptive design was chosen to characterise the existing state of soft skills, short course participation, and employment outcomes among the target population [22]. The mixed-methods approach, combining quantitative survey data with qualitative interview insights, enabled triangulation of findings and a more comprehensive understanding of the research phenomena than either method alone would permit [23].

### Population and Sample

The study population comprised graduates from the Class of 2025 at Golis University, New Generation University, and Admas University in Hargeisa, Somaliland. Golis University, founded in 2004, has a total enrollment exceeding 4,000 students across multiple campuses [24, 25]. Admas University College-Hargeisa, which commenced operations in 2006, accommodates over 3,000 students and has produced more than 7,000 graduates since its establishment [24]. New Generation University College, founded in 2010, operates three campuses in Hargeisa, Buroa, and Gabiley, with an estimated total of over 10,000 graduates across 13 batches and currently employs over 300 teaching staff [26].

Since no exact official records of graduate numbers for the Class of 2025 were available from the three institutions, the population was estimated at approximately 500+ graduates per university, totalling approximately 1,500+ graduates. This estimate was derived from consultations with alumni offices and academic registrars, based on provisional graduation lists and enrollment data for the 2024/2025 academic year. The sample size was determined using Slovin's formula:

$$n = N / (1 + Ne^2) = 1,500 / (1 + 1,500 \times 0.06^2) = 234.4.$$

The calculated minimum sample was approximately 235 respondents. Due to practical constraints including time, resource limitations, and the dispersal of graduates after completion, a final sample of 150 respondents was determined to be feasible and adequate. The sample was equally distributed across the three universities (50 respondents each), reflecting the approximate parity in their estimated graduate populations and ensuring equitable representation. Convenience sampling was employed, with respondents selected based on availability and accessibility [27].

### Instruments and Data Collection

Data were collected using a structured questionnaire comprising five sections: demographic information (Section A), soft

skills assessment using a 5-point Likert scale (Section B), short course participation history (Section C), job readiness indicators (Section D), and career improvement measures (Section E). The questionnaire was reviewed by two subject matter experts for content validity, achieving a Content Validity Index of 0.78. Reliability was assessed through a pilot study (n = 20), yielding Cronbach's Alpha values ranging from 0.79 to 0.87 across the instrument's subscales. Qualitative data were gathered through semi-structured interviews with 15 respondents (5 from each university), exploring their employment experiences, perceptions of soft skills importance, and views on professional development opportunities.

### Data Analysis

Quantitative data were analysed using SPSS version 26. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were computed to summarise respondent characteristics and variable distributions. Pearson correlation analysis was employed to examine relationships between soft skills and job readiness, and between short course participation and career improvement. A significance level of 0.05 was adopted for all inferential tests. Qualitative interview data were analysed thematically following Braun and Clarke's [28] six-phase process.

## Results

### Demographic Profile

A total of 150 graduates participated in the study, equally distributed as 50 respondents from each university. The demographic characteristics are presented in Table 1.

**Table 1.** Demographic Profile of Respondents (N = 150)

| Characteristic | Category | n | % |
|---|---|---|---|
| Gender | Male | 87 | 58.0 |
| | Female | 63 | 42.0 |
| Age | 20-24 years | 78 | 52.0 |
| | 25-29 years | 52 | 34.7 |
| | 30+ years | 20 | 13.3 |
| University | Golis University | 50 | 33.3 |
| | Admas University | 50 | 33.3 |
| | New Generation University | 50 | 33.3 |
| Employment | Employed | 39 | 26.0 |
| | Unemployed | 102 | 68.0 |
| | Further studies | 9 | 6.0 |

The gender distribution reflected typical patterns in Somaliland higher education, with male respondents comprising 58.0% of the sample. The majority (52.0%) were aged 20-24 years, consistent with the typical graduation age. Most notably, 68.0% of respondents were unemployed, underscoring the severity of graduate unemployment in the region.

### Soft Skills Levels

Table 2 presents the mean scores for each soft skill dimension, measured on a 5-point Likert scale.

**Table 2.** Soft Skills Levels among Graduates (N = 150)

| Soft Skill Dimension | Mean | SD | Level |
|---|---|---|---|
| Communication Skills | 2.30 | 0.92 | Low |
| Teamwork and Collaboration | 2.65 | 0.88 | Moderate |
| Problem-Solving Ability | 2.15 | 0.95 | Low |
| Critical Thinking | 2.08 | 0.91 | Low |
| Time Management | 2.42 | 0.87 | Low |
| Leadership Skills | 1.95 | 0.89 | Low |
| Emotional Intelligence | 2.12 | 0.93 | Low |
| Adaptability | 2.58 | 0.85 | Moderate |
| Overall | 2.28 | 0.78 | Low |

The overall mean score of 2.28 indicated low levels of soft skills across the sample. Leadership skills recorded the lowest score (M = 1.95), followed by critical thinking (M = 2.08) and emotional intelligence (M = 2.12). Teamwork (M = 2.65) and adaptability (M = 2.58) scored relatively higher, though still below the scale midpoint. These findings indicate pervasive soft skills deficiencies among the graduate population.

## Short Course Participation

Table 3 summarises the types of short courses attended by respondents.

**Table 3.** Short Courses Attended by Graduates (N = 150)

| Course Type | n | % |
|---|---|---|
| ICT/Computer Skills | 35 | 23.3 |
| Business Management | 22 | 14.7 |
| Entrepreneurship | 20 | 13.3 |
| Communication Skills | 18 | 12.0 |
| Project Management | 15 | 10.0 |
| Leadership Training | 12 | 8.0 |
| None attended | 55 | 36.7 |

A significant proportion (36.7%) had not attended any short courses. Among participants, ICT skills training was most common (23.3%), while communication skills courses, despite being highly relevant to identified gaps, were attended by only 12.0%. Of those who attended courses, 63.2% rated them as effective or very effective for enhancing employability.

## Correlation Analysis

Table 4 presents the Pearson correlation coefficients between soft skills dimensions and job readiness.

**Table 4.** Correlation between Soft Skills and Job Readiness

| Variable | r | p-value | Effect |
|---|---|---|---|
| Communication Skills | 0.712 | < 0.01 | Strong positive |
| Problem-Solving | 0.698 | < 0.01 | Strong positive |
| Teamwork | 0.654 | < 0.01 | Strong positive |
| Emotional Intelligence | 0.645 | < 0.01 | Strong positive |
| Critical Thinking | 0.621 | < 0.01 | Strong positive |

| | | | |
|---|---|---|---|
| Leadership | 0.603 | < 0.01 | Strong positive |
| Adaptability | 0.589 | < 0.01 | Moderate positive |
| Time Management | 0.578 | < 0.01 | Moderate positive |
| Overall Soft Skills | 0.682 | < 0.01 | Strong positive |

All correlations were statistically significant at $p < 0.01$. The overall correlation between soft skills and job readiness was strong and positive ($r = 0.682$). Communication skills demonstrated the strongest association with job readiness ($r = 0.712$). Additionally, a moderate positive correlation was found between short course participation and career improvement ($r = 0.548$, $p < 0.01$). Graduates who attended short courses reported an employment rate of 44.2%, compared to 16.4% among non-participants.

### Challenges in the Job Market

Table 5 identifies the challenges graduates reported facing in securing employment.

**Table 5.** Challenges Faced by Graduates in the Job Market (N = 150)

| **Challenge** | **n** | **%** |
|---|---|---|
| Lack of soft skills required by employers | 118 | 78.7 |
| Curriculum-market mismatch | 105 | 70.0 |
| Limited job opportunities | 92 | 61.3 |
| Inadequate practical training | 82 | 54.7 |
| Poor interview preparation | 76 | 50.7 |
| Lack of professional networks | 71 | 47.3 |
| Insufficient digital literacy | 65 | 43.3 |

The lack of soft skills was the most frequently cited challenge (78.7%), followed by curriculum-market mismatch (70.0%). Notably, graduates identified soft skills deficiencies as a more significant barrier than limited job opportunities, suggesting that employability challenges extend beyond structural labour market constraints.

## Discussion

The findings of this study offer important insights into the employability landscape confronting university graduates in Somaliland, with implications that resonate across the broader Sub-Saharan African context. The pervasive low levels of soft skills documented among respondents (overall M = 2.28) confirm that the gap between educational outputs and labour market expectations is not merely anecdotal but empirically substantiated. This observation aligns with the conclusions of Andrews and Higson [9], who argued that universities typically excel in developing technical knowledge while neglecting the interpersonal and professional competencies that employers prioritise. The particularly low scores for leadership (M = 1.95) and critical thinking (M = 2.08) are especially concerning, as these competencies underpin independent professional judgment and initiative, qualities increasingly valued in contemporary workplaces.

The strong positive correlation between soft skills and job readiness ($r = 0.682$) provides robust empirical support for Human Capital Theory [18, 19], which posits that investments in general human capital yield returns through enhanced employability. Communication skills emerged as the strongest predictor of job readiness ($r = 0.712$), a finding consistent with the National Association of Colleges and Employers [10] employer surveys and the observations of Robles [1], both of which identify communication as the paramount soft skill for workplace success. This result carries particular significance for Somaliland, where the Hargeisa Chamber of Commerce [4]

reported that over 70% of employers found recent graduates deficient in communication abilities.

The study's findings regarding short course participation reveal a paradox: while 36.7% of graduates had not attended any professional development programmes, those who did reported substantially better employment outcomes. The employment rate differential between course participants (44.2%) and non-participants (16.4%) represents a compelling indicator of the practical value of targeted skills training. This result supports Social Learning Theory [20], which emphasises the efficacy of experiential, practice-oriented learning environments in developing transferable competencies. The moderate positive correlation between short course participation and career improvement ($r = 0.548$) further corroborates the findings of Finch et al. [15] and Blunch and Castro [17], who documented positive employment effects associated with vocational and professional development programmes.

The finding that 78.7% of respondents identified soft skills deficiencies as their primary employment barrier challenges simplistic explanations of graduate unemployment that attribute the problem solely to limited job creation or economic stagnation. While 61.3% of respondents also cited limited job opportunities, the primacy of soft skills as a self-identified barrier suggests that even where employment vacancies exist, graduates may be unable to secure positions due to inadequate preparation for workplace demands. This interpretation is reinforced by employer reports from the Hargeisa Chamber of Commerce [4], which documented that 65% of employers found graduates lacking in teamwork abilities, and by the British Council [5] study, which identified similar patterns across multiple Sub-Saharan African countries.

The curriculum-market mismatch identified by 70.0% of respondents points to a systemic issue requiring institutional intervention. Higher education programmes in Somaliland, as in many developing countries, have historically emphasised theoretical knowledge transmission over applied competency development. The integration of soft skills training into curricula, experiential learning opportunities, and employer engagement in programme design represent potential avenues for addressing this disconnect. Career Development Theory [21] provides a useful lens for understanding these dynamics, conceptualising the school-to-work transition as a developmental stage in which the integration of self-concept with occupational competence determines success.

## Conclusion

This study provides empirical evidence that soft skills deficiencies and limited participation in professional development programmes constitute significant barriers to graduate employability in Somaliland. The strong correlation between soft skills and job readiness, combined with the substantial employment differential between short course participants and non-participants, underscores the critical importance of addressing these gaps through coordinated institutional and policy interventions.

Based on the findings, several recommendations are offered. Universities should integrate soft skills development into core curricula across all programmes, establishing dedicated courses in communication, teamwork, leadership, and problem-solving, while incorporating experiential learning approaches such as group projects, case studies, and simulations. Career development centres should be established to provide guidance, interview preparation, and skills assessment services. Partnerships between universities and employers should be strengthened to ensure curriculum relevance and facilitate work-integrated learning opportunities. Graduates should be encouraged to proactively pursue short courses and

professional development programmes, leveraging both institutional offerings and online platforms. Employers should invest in on-the-job soft skills training and mentorship for new hires. Finally, government agencies should support the establishment of vocational training centres and develop national qualifications frameworks that formally recognise and certify soft skills competencies.

The study's cross-sectional design and reliance on convenience sampling represent acknowledged limitations that suggest directions for future research. Longitudinal studies tracking graduates' career trajectories over extended periods, comparative analyses involving larger and more diverse institutional samples, and intervention studies evaluating the effectiveness of specific soft skills training programmes would extend the evidence base in this critical area.

## Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

## Ethical Approval

Ethical approval for this study was obtained from the Research Ethics Committee of New Generation University College, Hargeisa, Somaliland. All respondents provided informed consent prior to participation, and their anonymity and confidentiality were maintained throughout the research process.

## Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

## Author Contributions

Mumin Omar: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing - Original Draft, Writing - Review and Editing.

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