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Local Content Policies in Petroleum-Rich Nations: A Comparative View of Four Countries

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Abstract

Local Content Policies (LCPs) are essential for enhancing socio-economic benefits in the oil, gas, and mining sectors. This paper compares the LCPs of Guyana, Angola, Nigeria, and Trinidad and Tobago, focusing on their objectives, regulatory frameworks, and impacts. Guyana, with its recent oil discoveries, emphasizes local participation, while Angola and Nigeria implement stricter policies to maximize benefits from their established industries. Trinidad and Tobago prioritize sustainable development and local ownership, reflecting a more holistic approach to resource management. Angola and Nigeria's LCPs aim to enforce local participation and boost economic returns, but they face challenges like regulatory complexities and enforcement issues. In contrast, Trinidad and Tobago seeks to balance economic growth with environmental considerations, promoting collaboration among government, businesses, and communities. This inclusive approach may serve as a model for other countries aiming to enhance their LCP effectiveness. The study highlights common challenges across these nations, such as inconsistencies in regulations and enforcement difficulties that can limit LCP success. To improve outcomes, the paper recommends strengthening governance frameworks focused on transparency and accountability. By assessing the impacts of LCPs on job creation and economic development, the research aims to guide policymakers in ensuring fairer benefit distribution from natural resource exploitation.

Keywords: *Enforcement Challenges, Local Content Policies (LCPs), Resource Management, Socio-Economic Benefits, Sustainable Development.*

Introduction

Local Content Policies (LCPs) have emerged as pivotal instruments in the governance of natural resource extraction, particularly within the oil, gas, and mining sectors. These policies aim to maximize the socio-economic benefits derived from resource exploitation by promoting local participation in industry activities. However, the nature and effectiveness of LCPs vary significantly across nations hosting oil, gas, and mining operations.

Notably, the findings underscore how these countries' distinct economic landscapes and policy emphases within the petroleum sector have shaped their respective LCP frameworks and their outcomes. Each nation's approach to promoting local participation and economic benefits in the oil and gas industry reflects a blend of historical context, regulatory frameworks, and national development priorities.

This paper explores the comparative landscape of Local Content Policies across Oil, Gas, and Mining (OGM) nations, analyzing their objectives, regulatory frameworks, implementation strategies, and impacts on host economies. Specifically, key differences and commonalities in the design and implementation of LCPs across four diverse O&G nations within the Latin American countries, namely, Guyana, Angola, Nigeria, and Trinidad and Tobago are

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identified. In this context, we initially explore the study's purpose, which serves as the cornerstone guiding the investigation to address specific research questions. We then outline the methodology, detailing the approach and techniques employed for data collection and analysis. Subsequently, the paper delves into a discussion of the research findings, interpreting data, and drawing conclusions from the analysis conducted. Lastly, the paper summarizes the principal findings, identifies limitations, and provides recommendations for future research directions.

Purpose of the Study

This study aims to compare Local Content Policies in the oil and gas sectors of Guyana, Angola, Nigeria, and Trinidad and Tobago. By examining their objectives, regulatory frameworks, implementation strategies, and socio-economic impacts, the research will highlight key differences and similarities. It will also address common challenges like regulatory complexities and enforcement issues, drawing on global best practices to propose recommendations. Ultimately, the goal is to refine Local Content Policies in Guyana to enhance local participation, promote sustainable development, and ensure a fair distribution of benefits from resource extraction.

Research Questions

The following questions focus on comparing Local Content Policies across various nations, examining the nuances in their approaches, common challenges, and insights from global experiences to improve policy effectiveness.

1. How do Local Content Policies in Guyana, Angola, Nigeria, and Trinidad and Tobago differ in objectives, regulations, implementation, and socio-economic impacts?
2. What challenges and success factors impact Local Content Policies in these countries, and how can global best practices improve local participation and benefits?

Methods

The following approaches were utilized in synthesizing secondary sources to provide a comprehensive understanding of Local Content Policies in the specified countries, aiming to contribute insights and recommendations for policy development and refinement.

Literature Review

1. A comprehensive review of academic articles, books, reports, and policy documents related to Local Content Policies in the oil and gas sectors.
2. Identification of Key concepts, theories, and frameworks relevant to understanding the objectives, regulatory frameworks, implementation strategies, and impacts of Local Content Policies

Data Collection

1. Secondary data were gathered from reputable sources such as government publications, international organizations (e.g., World Bank, IMF), industry reports, and academic databases.
2. The focus was on collecting data on the evolution of Local Content Policies in each country, legislative mandates, industry practices, and documented socio-economic impacts.

Data Analysis

1. The data was analyzed to identify trends, patterns, and differences in the implementation and effectiveness of Local Content Policies across Guyana, Angola, Nigeria, and Trinidad and Tobago.
2. A process of comparing and contrasting policy objectives, regulatory frameworks, and strategies for promoting local participation and economic benefits in the oil and gas sectors was initiated.

Synthesis and Interpretation

1. The findings were synthesized to provide a comprehensive overview of the nuanced

approaches and common challenges faced by each country in implementing Local Content Policies.

2. The data was Interpreted to draw conclusions regarding the socio-economic impacts of these policies, including their effectiveness in fostering local economic development, job creation, and skills enhancement.

Results

Nigeria Local Content Policy and Petroleum Sector

Nigeria is one of the world's top 10 biggest oil-exporting countries, and the local oil industry contributes 80% and 95% of Nigeria's revenues and foreign exchange, respectively. The oil and gas deposit in the oil-rich Niger Delta region of the country has been the mainstay of the Nigerian economy and a major source of crude oil to meet part of the global demand for energy over several decades [2] and [16].

Before the enactment of the Nigerian Oil and Gas Industry Content Development Act 2010, Nigeria relied heavily on foreign procurement of goods and services [1]. The reliance on foreign-sourced materials and the attendant loss of income severely impacted the local economy. Despite the ingenuity of this act, the dissonance towards LCRs is hinged on the fact that local communities believe that their voices are not heard and respected in the decision-making process, as well as on the lack of procedural fairness in contract awarding and project management [25].

As illustrated in Table 1, the National Petroleum Corporation (NNPC) plays a pivotal role in Nigeria's oil and gas sector by implementing regulations aimed at maximizing local benefits through joint ventures and local content requirements. These policies are designed to foster economic growth and skill development within the country. By mandating local content quotas in contracts, NNPC seeks to ensure that a significant portion of oil and gas operations involve local businesses and talent, thereby boosting employment and transferring technical expertise to local industries. Despite these efforts, achieving consistent success in meeting local content targets has been mixed. Challenges such as regulatory inconsistencies and limited capacity in local industries have posed significant hurdles.

Ongoing efforts are underway to enhance transparency and strengthen enforcement mechanisms to overcome these barriers and ensure that the benefits of oil and gas extraction are more equitably distributed across Nigerian communities [21].

However, gaps remain in understanding the long-term socio-economic impacts of these policies on local communities. While local content requirements aim to stimulate economic diversification and reduce dependency on foreign expertise, their full effect on job creation, infrastructure development, and overall community welfare requires further research. Addressing these research gaps is crucial for refining policy approaches and ensuring that the benefits of Nigeria's natural resources are maximized in a sustainable manner. By refining regulatory frameworks and enhancing collaboration between government, industry, and local stakeholders, NNPC can better navigate these challenges and advance its goals of promoting local participation and economic development in the oil and gas sector.

Moreover, Nigeria currently ranks 15th globally in crude oil production, with an estimated output of approximately 1,251 million barrels. This region holds significant reserves, estimated at about 37.07 billion barrels, contributing substantially to the global energy landscape. The production of crude oil in Nigeria not only supports domestic energy needs but also plays a crucial role in international markets, influencing global supply dynamics and economic policies. See Table 2.

Table 1. Nigeria LCP Key Characteristics

Approach	Focuses on maximizing local benefits through joint ventures and local content requirements
Key Features	National Petroleum Corporation (NNPC) oversees regulations to ensure local participation.
Legislation	Policies mandate local content quotas in contracts to stimulate economic growth and skill development.
Impact	Mixed success in achieving local content targets, with ongoing efforts to enhance transparency and enforcement.
Gaps	Mixed success in achieving local content targets due to regulatory inconsistencies and limited capacity in local industries. Research gaps exist in understanding the long-term socio-economic impacts on local communities.

Source: [3] and [25]

Table 2. Nigeria Crude Oil Production and Ranking

Oil Reserve	About 37.7 billion barrels
Production Level	About 1,251 bpd of Crude oil
Ranking	No. 15th in Latin America (Crude oil Production)

Source: [20]

Angola Local Content Policy and Petroleum Sector

The Angolan government has implemented several legislative measures aimed at promoting local participation and development within the petroleum industry. Law 10/79 mandates Sonangol, the national oil company, to prioritize the employment and training of Angolan nationals. Decree 20/82 further supports this by outlining specific goals for the Angolanization of the industry's workforce. Law 14/03 establishes a comprehensive framework to enhance Angolan private enterprises across all economic sectors, including the petroleum industry. Decree 127/03 mandates the sourcing of goods and services locally for petroleum-related activities, boosting domestic industries [8] & [6].

Production sharing contracts include provisions for local content requirements, ensuring that a significant portion of operations benefit Angolan businesses and workers. Decree 13/10 protects nationals from discriminatory practices in hiring and remuneration.

Additionally, petroleum-sharing contracts specify stringent training requirements for Angolan workers and subcontractors, emphasizing skills development and sustainability in the sector [21]. In 2020, Angola produced, on average, 1.3 million barrels of oil daily, being the second largest oil producer in Africa. Angola's oil sector struggles with a lack of investment. Capital expenditure and investment in the industry declined to US$3 billion in 2021, against US$15 billion in 2014. The Angolan government has released a strategic plan for the exploration of hydrocarbons between 2020 and 2025 with the approval of new tax incentives to boost the oil industry [21].

Claire (2017) posits that within the last 40 years, the Angolan petroleum industry has undergone major structural, legal and fiscal changes to ensure equitable sharing of petroleum benefits. Nevertheless, those changes have not

been reflected positively in social development among Angolan citizens, thereby prompting the introduction of Local Content (LC) requirements. He argues that LC plays an important role in accelerating the process of benefit sharing.

However, the formulation and implementation thereof create discord between the stakeholders. Currently, LC has become a legal obligation that reflects the commitments undertaken by the exploration and production companies to acquire local labour, goods and services [14] and [12]. Under the Angolan petroleum legal regime, LC percentages are meant to generate economic benefits for the local economy that go beyond fiscal benefits [8].

As illustrated in Table 3, it is evident that the Angolan government has implemented robust legislative measures aimed at bolstering local employment and skill development within its petroleum industry, primarily through mandates imposed on entities like Sonangol, the national oil company. Laws such as Law 10/79 and Decree 20/82 are pivotal in this effort by stipulating requirements for the prioritization of Angolan nationals in employment and training within the sector. These regulations are designed not only to enhance workforce participation but also to build local capacity, ensuring that Angolans are equipped with the necessary skills to contribute meaningfully to the oil and gas industry. Despite these initiatives, challenges persist, particularly in enforcing these mandates effectively and ensuring transparency in contract awards. Issues such as equitable distribution of economic benefits among local communities also pose significant hurdles that require continuous attention and improvement.

Furthermore, the impact of technology transfers and sustainable development practices in Angola's petroleum sector remains a subject of ongoing study and scrutiny. While efforts are made to integrate technology and sustainable practices into operations, more comprehensive research is needed to assess their long-term socio-economic effects.

Understanding these dynamics is crucial for refining policies that not only meet immediate employment and capacity-building goals but also contribute to sustainable development and broader economic diversification in Angola.

Additionally, Angola ranks 16th globally in crude oil production, with an estimated output of approximately 1.1 million barrels per day (bpd) and holding significant reserves of about 9.0 billion barrels (refer to Table 4). According to the Country Commercial Guide (2024), the country's petroleum sector plays a crucial role in its economy, contributing substantially to both domestic energy needs and international markets. Angola's oil production supports various socio-economic initiatives, including local employment and skill development efforts mandated by legislative measures aimed at enhancing national participation in the industry [21].

Notably, Angola and Nigeria are countries from Latin America and Africa that have established an official local content policy and have been implementing it for many years. Producing countries in Latin America and Africa that have established frameworks to promote employment, national industry participation, and skills development. For instance, in countries such as Bolivia, Colombia, and Ecuador, there is no specific legislation for local content in the oil and gas sector. Nonetheless, there are regulations contained in different frameworks that seek to promote national employment and local sourcing practices [12] and [9].

Table 3. Angola LCP Key Characteristics

Approach	Aims to enhance local employment and skill development through mandates on companies like *Sonangol.
Key Features	National Petroleum Corporation (NNPC) oversees regulations to ensure local participation.

Legislation	Legislation such as Law 10/79 and Decree 20/82 enforce local hiring and training requirements.
Impact	Significant local employment and capacity building in the petroleum sector, although challenges with enforcement and transparency persist.
Gaps	Challenges include transparency in awarding contracts and ensuring equitable distribution of benefits among local communities. More studies are needed to evaluate the impact of technology transfer and sustainable development.

*Sonangol is the abbreviation for "Sociedade Nacional de Combustíveis de Angola," which translates to the National Fuel Society of Angola in English. Sonangol is the state-owned oil company of Angola and is responsible for overseeing the exploration, production, refining, and marketing of petroleum products in the country.

Source: [22], [6], [21], and [24]

Table 4. Angola Crude Oil Production and Ranking

Oil Reserve	About 9.0 billion barrel
Production Level	About 1.1 million bpd of Crude oil
Ranking	No. 16th in Latin America (Crude oil Production)

Source: [20]

Trinidad & Tobago Local Content Policy and Petroleum Sector

Trinidad's emphasis on local content underscores a strategic commitment to prioritize businesses that are locally owned, controlled, and financed. This prioritization is not merely economic but also resonates with the cultural and developmental aspirations of the country. By supporting indigenous enterprises, Trinidad aims to enhance its economic resilience and promote sustainable growth. This approach not only fosters a sense of national pride and ownership but also ensures that the benefits of economic activities contribute significantly to local communities and broader societal goals. Moreover, by encouraging local value-added initiatives, Trinidad seeks to maximize participation and capability development, aligning closely with its long-term vision for socio-economic advancement [5].

This suggests that Trinidad's policy on local content reflects a nuanced understanding of global economic dynamics while safeguarding its own interests and developmental goals. By encouraging businesses that demonstrate a clear commitment to maximizing local value-added, the country ensures that economic benefits are retained within its borders, fostering a more inclusive and equitable growth trajectory. This strategy not only bolsters local industries but also enhances their competitiveness on the global stage by nurturing capabilities and fostering innovation domestically. As Trinidad continues to evolve its approach to local content, it remains dedicated to aligning economic activities with its broader national aspirations, ensuring sustainable development that benefits both present and future generations.

Expanding Table 5 reveals that T&T places a strong emphasis on sustainable development and local participation within its mature oil and gas sector. This focus is reflected in both stricter environmental regulations and incentives aimed at fostering greater involvement of local businesses. The Ministry of Energy and Energy Industries plays a pivotal role in overseeing

policies that seek to balance economic growth with environmental sustainability. By promoting local content participation, Trinidad aims to bolster its economy through increased employment opportunities and supplier development within the oil and gas industry. However, despite these efforts, challenges persist, particularly in diversifying the economy beyond oil and gas. Sustainable development practices remain a priority, necessitating ongoing research and evaluation of the effectiveness of incentives designed to encourage local participation in the sector.

Additionally, T&T is endowed with an estimated 9.0 billion barrels of oil reserves, representing a significant asset within the region. The country's oil production stands at approximately 55 thousand barrels per day (bpd) of crude oil, contributing substantially to its economic landscape. This production level positions Trinidad as the 16th largest producer of crude oil in Latin America, highlighting its role within the regional energy sector (refer to Table 6). This suggests that the country's oil reserves and production Tables underscore its importance in the global energy market and its ongoing efforts to leverage these resources for economic development and sustainability.

Table 5. Trinidad & Tobago LCP Key Characteristics

Approach	Emphasizes sustainable development and local participation in its mature oil and gas sector.
Key Features	Stricter environmental regulations and incentives for local content participation
Legislation	The Ministry of Energy and Energy Industries oversees policies to balance economic growth with environmental sustainability.
Impact	Established framework with significant local employment and supplier development, but challenges with diversification remain.
Gaps	Challenges include the need for greater diversification beyond the oil and gas sector and ensuring sustainable development practices. Further research is needed on the effectiveness of incentives for local content participation.

Source: [5], [18], and [19]

Table 6. Trinidad & Tobago Crude Oil Production and Ranking

Oil Reserve	About 9.0 billion barrels
Production Level	About 55 thousand bpd of Crude oil
Ranking	No. 16th in Latin America (Crude oil Production)

Source: [20]

Guyana Local Content Policy and Petroleum Sector

Since the discovery of significant petroleum reserves in 2015, the Government of Guyana (GoG) has prioritized the involvement of Guyanese citizens in the sector. In 2017 and 2018, the Ministry of Natural Resources developed two drafts of a local content policy for public feedback.

The second draft underwent extensive consultation with stakeholders from various sectors and regions, incorporating an

implementation strategy and framework for a detailed plan. By 2019, the GoG revised and expanded the policy into a third draft, which included a comprehensive implementation plan. This version was further refined by a team from the Commonwealth Secretariat (CS), resulting in a detailed report for Guyana's government. It provided guidance on implementation, drawing from regulatory insights and experiences in other oil-producing nations, including those new to the industry. The finalized report was published in January 2020 [11].

Notably, Guyana's significant success in exploration, including major discoveries in oil and gas with low production costs, has drawn considerable attention to the value generated by activities related to ongoing exploration, field development, and the utilization and sale of high-quality oil and associated gas products. Despite these achievements, a substantial portion of the services necessary for oil field development continue to be imported into Guyana during the initial phases of oil production and exportation. These services demand expertise, technology, equipment, facilities, infrastructure, and capital, many of which are still in the nascent stages of development within the local market.

Moreover, Guyana's recent petroleum discoveries coincide with those of other developing countries undergoing potentially transformative changes. Many of these nations have introduced local content policies and laws, each with differing levels of success.

Meanwhile, established oil and gas regions with significant recent discoveries have utilized their experiences to either implement or refine local content policies and strategies. Guyana is uniquely positioned to draw from a spectrum of these experiences in crafting its own policy and implementation strategy.

As a new industry, there is an opportunity to design and operate the required governance framework, institutions, and legal and regulatory instruments (including policies, legislation, regulations, contracts, licenses, permits, decision-making criteria, reporting requirements, guidelines, and procedures) to the highest standards required. Done well, this will ensure transparent and accountable management of the resource and can become a catalyst for the transformation of the governance of the entire country and economy [11].

As illustrated in Table 7, Guyana's aspirations in its emerging oil sector centred on fostering local participation and reaping economic benefits. Key objectives include stimulating local job creation, advancing skills among its workforce, and prioritizing the procurement of goods and services from domestic sources. To bolster its capabilities, Guyana is strategically partnering with international firms, aiming to enhance local capacity and infrastructure through collaborative efforts. In these initial stages of implementation, the focus remains on maximizing contributions to local content, aiming to ensure that the benefits of oil exploration and production are widely felt within the country.

However, despite these efforts, there remains a dearth of comprehensive data on the actual impact of local content policy (LCP) implementation on local employment rates and the development of indigenous industries. The need for further research is crucial to assess compliance with local content regulations and to gauge the effectiveness of these policies in achieving their intended economic and developmental outcomes. This ongoing evaluation will be essential in refining strategies and ensuring that Guyana optimally harnesses its newfound oil resources for sustainable growth and broad-based prosperity.

Additionally, Guyana boasts substantial oil reserves estimated at approximately 11.0 billion barrels, underscoring its emerging prominence in the global energy landscape. The country's current production level stands at around 645 thousand barrels per day (bpd) of crude oil, a testament to its growing capacity in the oil sector. This output positions Guyana as the 17th largest producer of crude oil in Latin America, marking a notable ascent in regional rankings (refer to Table 8). As Guyana continues to develop its oil industry, these reserves and production Tables are

pivotal in shaping its economic trajectory and enhancing its strategic importance within the global energy market.

Table 7. Guyana LCP Key Characteristics

Approach	Aims to promote local participation and economic benefits from its burgeoning oil industry.
Key Features	Focus on local job creation, skills development, and procurement of goods and services locally.
Legislation	Emphasis on partnerships with international companies to enhance local capacity and infrastructure.
Impact	Early stages of implementation with efforts to maximize local content contributions.
Gaps	Limited data on the actual impact of LCP implementation on local employment rates and the development of local industries. Further research is needed to assess compliance and effectiveness.

Source: [11] and [4]

Table 8. Guyana Crude Oil Production and Ranking

Oil Reserve	About 11.0 billion barrels
Production Level	About 645 thousand bpd of Crude oil
Ranking	No. 17th in Latin America (Crude oil Production)

Source: [20] and [11]

Discussion

This comparative analysis highlights the diverse approaches and outcomes of LCPs in Guyana, Angola, Nigeria, and Trinidad and Tobago, reflecting their unique economic contexts and policy priorities in the petroleum industry. Notably, across various countries implementing Local Content Policies (LCPs) in their oil sectors, similarities and differences emerge. All nations emphasize local job creation, skills development, and the procurement of goods and services domestically as core objectives within their LCP frameworks.

However, differences arise in the enforcement mechanisms, regulatory frameworks, and the maturity of their respective industries, which significantly impact the effectiveness of these policies. Some countries may face challenges in maintaining transparency, ensuring robust enforcement, and striking a balance between economic gains and environmental sustainability, which are common hurdles encountered in LCP implementation.

Despite these differences, there are common themes and lessons learned from the implementation of LCPs. Case studies from countries like Norway and Australia highlight successful strategies in leveraging local content policies to foster technology transfer, skills development, and job creation within the O&G sector [22].

These countries have effectively balanced the need to attract foreign investment by ensuring substantial local economic benefits, offering valuable insights for other resource-rich nations.

Various countries adopt LCPs tailored to their specific economic and developmental goals. For instance, countries like Brazil and Nigeria have established stringent local content requirements to promote indigenous participation in the oil and gas value chain [23]. In contrast, emerging O&G nations such as Guyana are in the early stages of implementing and refining their LCP frameworks to capitalize on newfound resource wealth [13].

Challenges associated with LCPs include regulatory complexity, enforcement issues, and the risk of unintended market distortions. However, best practices emerge from experiences where transparent governance, stakeholder engagement, and continuous monitoring have been prioritized [7]. Lessons from advanced economies show that phased implementation, capacity building, and collaboration between government, industry, and civil society are crucial for maximizing the effectiveness of LCPs [17].

In 2022, Guyana revised and enacted the Natural Resource Fund (NRF) to govern the financial earnings derived from the exploitation of its natural resources. This legislative framework ensures that the utilization of these earnings aligns with principles of good governance and international best practices, including adherence to the Santiago Principles [2]. The NRF is designed to manage and allocate revenues responsibly, aiming to maximize long-term benefits for the country's economy and population. These principles emphasize key aspects such as governance, accountability, transparency, and investment management practices. By integrating these principles into the NRF, Guyana aims to safeguard its natural resource wealth, mitigate fiscal risks, and promote sustainable development [11].

Looking ahead, the future direction for countries lies in the continuous refinement of their LCPs. This involves enhancing regulatory frameworks, building local capacities, and addressing sector-specific challenges to maximize the benefits accrued locally from oil sector activities. By refining policies and bolstering enforcement measures, countries can better ensure that their LCPs contribute meaningfully to sustainable economic development and inclusive growth within their borders.

Moreover, the risks associated with the unsuccessful implementation of local content policies, as seen in past experiences, coupled with the potential for political interference, underscore the need for a comprehensive legislative study on optimizing benefits from oil exploitation. Effective policies must be tailored to the specific context of each country to mitigate supply bottlenecks, skills gaps, and corrupt practices. Temporary protection of local entities from foreign competition should aim at fostering local capacity growth, with a long-term goal of achieving high performance, productivity, and competitiveness. Failure to adopt such an approach risks higher costs, longer project timelines, and lower quality outputs from local suppliers compared to foreign counterparts, ultimately impacting operators' profits and government tax revenues adversely [10].

Furthermore, local firms typically encounter restricted access to finance, particularly challenging for Small and Medium Enterprises (SMEs) facing high interest rates, stringent collateral requirements, and lacking expertise in developing compelling business plans for loan applications [10]. Transparency in communicating business opportunities created by local content policies is crucial. If these opportunities are not publicly disclosed and instead controlled by government officials or economic elites, it could lead to exclusive access to contracts and services, limiting competition and efficiency. This scenario could result in economic inefficiencies and welfare losses compared to a more open and competitive business environment [15].

Key Differences

Guyana, Angola, Nigeria, and Trinidad and Tobago each have unique local content strategies in their oil and gas sectors. Guyana aims for local participation and diversification, Angola focuses

on workforce skills and reducing foreign reliance, Nigeria prioritizes Indigenous company growth amid governance issues, and Trinidad and Tobago promotes the local industry through a hybrid regulatory model. These differences are outlined below and discussed within four contexts.

Objectives

1. **Guyana:** Focus on maximizing local participation and economic diversification.
2. **Angola:** Aims to enhance local workforce skills and reduce reliance on foreign firms.
3. **Nigeria:** Prioritizes indigenous company development and economic empowerment.
4. **Trinidad and Tobago:** Seeks to foster local industry growth and technology transfer.

Regulatory Frameworks:

1. **Guyana:** New and evolving regulations aligned with recent discoveries.
2. **Angola:** Established policies with specific local content quotas.
3. **Nigeria:** Comprehensive legal framework with penalties for non-compliance.
4. **Trinidad and Tobago:** Hybrid model combining regulations and incentives.

Implementation Strategies:

1. **Guyana:** Collaborative partnerships with international firms.
2. **Angola:** Emphasis on local company joint ventures.
3. **Nigeria:** Mandated local participation percentages in contracts.
4. **Trinidad and Tobago:** Public-private partnerships and capacity building.

Socio-Economic Impacts:

1. **Guyana:** Emerging opportunities in various sectors.
2. **Angola:** Mixed results; some success in job creation but ongoing challenges.
3. **Nigeria:** Significant local content growth but issues with corruption and governance.
4. **Trinidad and Tobago:** Relatively strong local sector but dependency on oil prices.

Limitation

This section provided a detailed exploration of the challenges and obstacles encountered in the effective implementation of Local Content Policies within the four countries under review. It underscored the various limitations and barriers that impact the execution and enforcement of these policies, shedding light on the complexities and nuances involved in ensuring compliance and achieving desired outcomes in each respective context.

Nigeria:

Local Community Engagement:

Local communities in Nigeria feel marginalized and believe their voices are not adequately heard in decision-making processes regarding local content policies.

Regulatory Inconsistencies:

Nigeria faces challenges due to inconsistencies in local content regulations, which hinder effective policy implementation and enforcement (Investment Climate Statements.

Capacity Limitations:

There is limited capacity within local industries in Nigeria to fully meet local content requirements, impacting the achievement of policy targets (Investment Climate Statements.

Impact Assessment Gaps:

There is insufficient data and research on the long-term socio-economic impacts of local content policies on Nigerian communities and industries (Investment Climate Statements.

Angola:

Enforcement Issues:

Angola encounters challenges in enforcing local content mandates effectively, particularly in ensuring transparency in contract awards and equitable distribution of economic benefits.

Skills Development:

Despite efforts in Angola to enhance local skills through training requirements, there are gaps in achieving comprehensive skills development across the petroleum sector.

Trinidad and Tobago:

Economic Diversification:

Trinidad and Tobago faces challenges in diversifying its economy beyond the oil and gas sector, limiting broader socio-economic benefits from local content policies.

Sustainable Development:

There is a need for Trinidad and Tobago to strengthen sustainable development practices within its oil and gas sector, highlighting gaps in policy effectiveness.

Guyana:

Data Deficiency:

Guyana lacks comprehensive data on the actual impact of its local content policy on local employment rates and the development of indigenous industries.

Financial Constraints for SMEs:

Local firms in oil-producing countries face challenges accessing finance, particularly SMEs grappling with high interest rates and stringent collateral requirements.

Recommendation

Enhanced Stakeholder Engagement

Prioritize meaningful engagement with local communities throughout the policy revision/development, implementation, and evaluation phases.

Streamlined Regulatory Frameworks

Harmonizing and simplifying local content regulations to reduce inconsistencies and enhance compliance. Clear and predictable regulatory frameworks can encourage investment and facilitate smoother implementation of local content requirements.

Capacity Building Initiatives

Focus on robust capacity-building programs aimed at enhancing local skills and capabilities within the petroleum sector. This includes targeted training programs, partnerships with educational institutions, and initiatives to transfer technology and expertise to local industries.

Comprehensive Impact Assessments

Rigorous and continuous impact assessments of local content policies. This involves gathering comprehensive data on employment rates, skills development, economic diversification, and broader socio-economic impacts to inform evidence-based policy adjustments and improvements.

Enhanced Enforcement Mechanisms

Strengthen enforcement mechanisms to ensure compliance with local content mandates. This includes increasing transparency in contract awards, monitoring adherence to local content quotas, and imposing penalties for non-compliance to deter violations.

Promotion of Sustainable Development

Prioritize integrating sustainable development practices into its local content policies. This involves setting clear environmental standards, promoting energy efficiency, and encouraging investments in renewable energy sources to reduce dependency on fossil fuels.

Support for SMEs

Implement policies to facilitate access to finance for local SMEs involved in the oil and gas supply chain. This includes providing financial incentives, reducing bureaucratic hurdles for loan applications, and offering technical assistance to strengthen business planning and management skills).

Transparency and Accountability

Establishing mechanisms for transparent governance and accountability in managing revenues from oil and gas resources, as seen in Guyana's Natural Resource Fund, can mitigate

risks of corruption and ensure funds are used for sustainable development.

Knowledge Sharing and Collaboration

Engage in knowledge sharing and collaboration with other resource-rich nations that have successfully implemented local content policies. Learning from global best practices and adapting them to local contexts can accelerate policy effectiveness and outcomes.

Continuous Monitoring and Evaluation

Robust monitoring and evaluation framework for assessing the effectiveness of local content policies over time. Regular reviews and adjustments based on evaluation findings can help countries optimize policy outcomes and address emerging challenges effectively.

Conclusion

In conclusion, the analysis of local content policies (LCPs) in Nigeria, Angola, Trinidad & Tobago, and Guyana reveals both common challenges and unique approaches tailored to their respective economic contexts and developmental goals within the petroleum sectors. Each country has implemented LCPs to varying degrees of success, aiming to maximize local economic benefits, enhance skills development, and promote sustainable growth.

Key findings indicate that while LCPs have facilitated local industry participation and contributed to economic diversification, significant challenges remain. These include regulatory inconsistencies, enforcement gaps, transparency issues in contract awards, and the need for robust capacity-building initiatives. Despite these challenges, there are notable successes in local job creation, skills transfer, and the promotion of indigenous industries across these nations.

The enhancement of local content policies (LCPs) across Nigeria, Angola, Trinidad & Tobago, and Guyana involves several key strategies. These include prioritizing inclusive consultations to build transparency and trust among stakeholders, simplifying and harmonizing regulatory frameworks to attract investment, and investing in local skills and technology to boost industry competitiveness. Regular impact assessments inform evidence-based policy adjustments, while stronger enforcement mechanisms and transparency in contract awards ensure compliance. Integrating sustainable development principles supports environmental goals, and supporting SMEs through improved access to finance fosters their growth in the oil and gas sector. Establishing transparent governance frameworks and learning from global best practices enhance policy effectiveness, alongside continuous monitoring and evaluation to optimize outcomes.

Conflict of Interest

This research is conducted with a commitment to integrity and objectivity, ensuring that there are no conflicts of interest.

The analysis of LCPs focuses exclusively on the objectives and impacts in Guyana, Angola, Nigeria, and Trinidad and Tobago. There are no personal or financial connections to the industries being studied, allowing for an unbiased evaluation of the regulatory frameworks and their socio-economic outcomes.

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Impact of AI Technologies in Optimizing Manufacturing Processes in Manufacturing Industry in Nigeria

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Abstract

This research examined the impact of Artificial Intelligence (AI) technologies on optimizing manufacturing processes in Nigeria's manufacturing industry, emphasising critical outcomes such as efficiency, productivity, and product quality. Data were obtained using structured questionnaires from a sample of 301 respondents from Dangote Cement Plc. and Nigerian Breweries Plc. The outcomes were examined using multiple regression models. The results indicated a substantial positive correlation between AI adoption and manufacturing efficiency, with AI facilitating enhancements in operational performance, minimising downtime, and improving decision-making. The investigation indicated that bigger organisations achieve better productivity enhancements from AI owing to their ability to absorb early expenses, while the skill level of the workforce further intensifies the advantages of AI integration. Furthermore, AI markedly enhanced product quality through real-time monitoring and predictive analytics. These findings align with worldwide literature, emphasising AI's transformational capacity in the manufacturing industry. The research determined that the adoption of AI is crucial for attaining competitive advantages in Nigeria's manufacturing sector and advised focused investments in infrastructure, workforce development, and conducive government policies to promote extensive AI integration.

***Keywords*:** Artificial Intelligence (AI), Efficiency, Manufacturing Processes, Optimization, Productivity, Product Quality

Introduction

Numerous impediments hinder the optimal functioning of Nigerian manufacturing. These encompass substandard infrastructure, inconsistent power supply, inefficient manufacturing processes, excessive production costs, and a deficiency of skilled workers. The structural deficiencies have led to the persistent underperformance of the Nigerian manufacturing sector, resulting in the nation's relatively low manufacturing output in comparison to other emerging economies [1]. Moreover, the industry has a low acceptance rate of technology, particularly regarding automation and process optimisation. The outcome is an industrial sector characterised by low productivity, inefficiency, and substandard product quality.

Numerous issues have been resolved by artificial intelligence (AI) technology. Manufacturers might potentially mitigate traditional inefficiencies in their production processes by leveraging AI's ability to analyse vast datasets, automate repetitive tasks, and facilitate predictive maintenance. Nonetheless, the Nigerian manufacturing sector is adopting AI at a minimal rate, mostly due to the high initial investment required, the lack of infrastructure, and the inadequate comprehension of AI applications among industry stakeholders [2]. This study aims to bridge the knowledge gap by examining the application of AI technologies in optimising

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manufacturing processes within the Nigerian context.

An effort has been initiated to tackle the challenges confronting the Nigerian manufacturing sector. The modernisation of manufacturing techniques via automation and digitalisation has increasingly attracted attention throughout time. To enhance operational efficiency, several manufacturing firms have used enterprise resource planning (ERP) software, industrial automation technologies, and information technology (IT) systems. While these systems have enhanced efficiency to some extent, they often lack the adaptive problem-solving capabilities afforded by AI technology [3].

Artificial Intelligence is employed worldwide in industry to enhance operational efficiency by minimising downtime, optimising resource allocation, and improving quality control. Enterprises in advanced economies have employed machine learning models to predict equipment failures and save maintenance expenses, resulting in a significant enhancement in production. AI-powered robots are employed to automate tedious tasks, liberating human resources for more complex problem-solving and strategic decision-making. AI-driven quality control systems may detect defects at various stages of the production process, reducing waste and ensuring superior quality goods [4].

Due to its scalability, versatility, and potential for continuous learning, artificial intelligence (AI) technologies are distinguished as one of the most promising solutions for industrial process optimisation. AI-powered systems can evaluate substantial amounts of real-time data, generating insights that enable producers to make timely, educated decisions. Beyond proactively scheduling maintenance and predicting equipment failures, machine learning algorithms help reduce downtime and decrease the expenses associated with unanticipated breakdowns. Artificial Intelligence systems may be integrated into supply chain management, product distribution, and other production stages, leading to a more cohesive and efficient manufacturing ecosystem [5].

The use of AI in the Nigerian manufacturing industry, despite its potential, is hindered by several challenges. These encompass substantial initial startup costs, a scarcity of AI expertise, inadequate digital infrastructure, and company executives' resistance to change. Moreover, the irregular power supply in Nigeria significantly complicates the implementation of AI solutions, as reliable electricity is essential for the optimal operation of AI-driven systems. A significant barrier to the extensive adoption of AI is the lack of regulatory frameworks and governmental support aimed at facilitating its incorporation into manufacturing processes. Nonetheless, AI possesses the power to significantly enhance Nigeria's industrial sector via appropriate investments in infrastructure, capacity development, and legislative reforms [6].

Industries employing AI technology report significant enhancements in productivity and profitability worldwide. AI-driven systems enhance decision-making by identifying patterns and trends in large datasets that human operators may miss. These insights enable organisations to maximise resource utilisation, reduce waste, and optimise production schedules. AI-driven predictive maintenance has reduced downtime in the automobile sector by as much as 30%, leading to substantial cost savings [7].

In Nigeria, several large-scale enterprises, especially within the fast-moving consumer goods (FMCG) and cement sectors, have commenced the exploration of AI applications. For instance, enterprises like Dangote Cement have commenced the utilisation of AI-driven systems to oversee and enhance production processes, resulting in significant efficiency gains. Nonetheless, these achievements are predominantly confined to large firms and the wider manufacturing sector.

This study aims to analyse the influence of AI technology on enhancing manufacturing processes within Nigeria's manufacturing sector. The study aims to identify the key factors affecting AI adoption, assess the effects of AI-driven optimisations on productivity, efficiency, and profitability, and investigate how AI applications might be utilised to enhance product quality and increase manufacturing output.

The study were guided by the following hypotheses:

H_1: There is a significant relationship between critical factors (e.g., infrastructure, workforce skill level, and cost) and the successful optimization of manufacturing processes using AI technologies.

H_2: AI-driven optimizations have a positive impact on efficiency, productivity, and profitability in the Nigerian manufacturing industry.

H_3: AI applications significantly enhance product quality and improve manufacturing output in Nigeria's manufacturing sector.

Methods

The study adopted a descriptive research design combined with quantitative analysis. This design is appropriate for understanding how AI technologies impact manufacturing processes in Nigeria by identifying patterns, correlations, and potential causal relationships between AI adoption and manufacturing outcomes such as efficiency, productivity, and product quality. The use of structured questionnaires provided a systematic approach for gathering data, while regression analysis enables the testing of hypotheses and the modeling of relationships between variables.

The population for this study included two well-known Nigerian businesses, Nigerian Breweries Plc. and Dangote Cement Plc., both of which are based in Lagos state, Nigeria.

This study project employs a probability sampling technique. Thus, Stratified random sampling is the method that is thought to be the most suitable. Stratified random sampling is a technique that involves dividing a population into discrete strata or subgroups according to shared characteristics. Distinct strata include, for instance, various departments within a company. The relative representation of each stratum in the population is then taken into consideration when choosing a sample at random from each stratum. This method ensures that each subgroup in the sample is sufficiently represented, which is crucial in diverse populations like those of Nigerian Breweries Plc and Dangote Cement Plc. The following justifications supported the choice of a stratified random sample for the current study:

Ensuring Compatibility: The sample is guaranteed to be representative of all pertinent departments, including information technology, production and operations, supply chain and logistics, human resources, and finance and accounting, by using stratified random sampling. This is a crucial factor to take into account because each department has a unique viewpoint on how artificial intelligence will impact their operations.

Decreased Bias: In order to reduce the likelihood of sampling bias and guarantee that the sample accurately represents the range of traits found in the community, participants within each stratum are chosen at random. A commonly used formula for sample size determination in stratified random sampling is:

$$\mathrm{n} = \frac{N \times Z2 \times p \times (1-p)}{e2 \times (N-1) + Z2 \times p \times (1-p)}$$

Where:

n = required sample size

N = total population size (3,570 employees from both companies)

Z = Z-value (the number of standard deviations corresponding to the desired confidence level, typically 1.96 for a 95% confidence level)

p = estimated proportion of the population (assumed to be 0.5 for maximum sample size)

e = margin of error (typically set at 0.05)

Substituting the values into the formula:

$$\frac{n = 3570 \times 1.962 \times 0.5 \times 0.50}{052 \times (3570 - 1) + 1.962 \times 0.5 \times 0.5}$$

The estimated sample size for this study is around 347 participants. A sample size of 347 employees, chosen using stratified random sampling from the departments of Dangote Cement Plc. and Nigerian Breweries Plc., will be adequate to yield statistically dependable findings on the influence of artificial intelligence on business process automation in the Nigerian manufacturing sector. Employing a stratified random sample approach guarantees that every pertinent department is sufficiently included in the study, so offering a thorough comprehension of the influence of AI across many aspects of the manufacturing process. The determined sample size of 347 participants is both feasible and statistically robust, guaranteeing that the study's results are applicable and dependable. This sampling method is consistent with the study's aims and enhances the credibility of the research results.

The primary data for this study was collected using a structured questionnaire. The questionnaire was designed to capture information on the extent of AI adoption, the specific AI technologies in use, and their perceived impact on manufacturing processes. It was divided into sections, each corresponding to one of the research objectives:

Section A: Demographic information of respondents (e.g., industry type, firm size, role of respondent)

Section B: AI adoption and usage (e.g., types of AI technologies implemented, duration of AI use)

Section C: Impact of AI on efficiency, productivity, and profitability

Section D: AI's effect on product quality and overall output

The questionnaire used a Likert scale (ranging from 1 to 5, with 1 being "strongly disagree" and 5 being "strongly agree") to measure respondents' views on various AI-related impacts. The questionnaire was administered to senior management and technical staff directly involved in the decision-making and operation of AI technologies within their firms. A total of 301 valid answers were collected from people in a variety of areas, including administration, technical/engineering, management, and operations.

Data Analysis Method

The initial phase of the data analysis entailed descriptive statistics, which encapsulate the principal attributes of the data. The figures encompassed mean, standard deviation, frequency, and percentages, offering insights on the extent of AI use and its perceived influence on manufacturing processes.

The essence of the data analysis was employing multiple regression analysis to investigate the correlations between AI adoption and the optimisation of manufacturing processes. The regression model assesses the impact of AI deployment on manufacturing efficiency, productivity, profitability, and product quality.

Model Specification

The regression model employed in this study was founded on the research objectives and assumptions. The dependent variables were efficiency, productivity, profitability, and product quality, whereas the independent variable was AI adoption, quantified by the degree to which enterprises have incorporated AI technology into their manufacturing processes. Control variables, including firm size, industry type, and worker skill level, were incorporated to account for external influences that may affect manufacturing performance.

The general form of the regression equation is:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \epsilon$$

Where:

Y_i = Manufacturing process optimization (measured by efficiency, productivity, profitability, or product quality)

β_0 = Constant (intercept)

X_1 = AI adoption level (e.g., types of AI technologies implemented)

X_2 = Firm size (control variable)

X_3 = Industry type (control variable)

ϵ = Error term

Regression Model for Hypothesis Testing

Hypothesis 1 (H_1): There is a significant relationship between critical factors (e.g., infrastructure, workforce skill level, and cost) and the successful optimization of manufacturing processes using AI technologies.

$$Efficiency = \beta_0 + \beta_1(AI_Adoption) + \beta_2(Infrastructure) + \beta_3(Workforce_Skill) + \epsilon$$

Hypothesis 2 (H_2): AI-driven optimizations have a positive impact on efficiency, productivity, and profitability in the Nigerian manufacturing industry.

$$Productivity = \beta_0 + \beta_1(AI_Adoption) + \beta_2(Firm_Size) + \beta_3(Industry_Type) + \epsilon$$

Hypothesis 3 (H_3): AI applications significantly enhance product quality and improve manufacturing output in Nigeria's manufacturing sector.

$$Product_Quality = \beta_0 + \beta_1(AI_Adoption) + \beta_2(Firm_Size) + \beta_3(Workforce_Skill) + \epsilon$$

In these equations, AI Adoption denotes the degree of AI utilisation by manufacturing businesses, whilst infrastructure, workforce skill level, firm size, and industry type serve as control variables that account for contextual elements affecting the manufacturing process.

Validity and Reliability

A pilot test was done with a limited selection of manufacturing enterprises to validate the questionnaire prior to the comprehensive data gathering. The pilot test facilitated the refinement of the questionnaire items, enhancing both clarity and relevance. Content validity was established by matching the questions with the research goals and consulting specialists in manufacturing and AI technology.

The reliability was evaluated by the Cronbach's Alpha test, which analysed the internal consistency of the questionnaire questions. A Cronbach's Alpha score of 0.70 was deemed adequate for dependability.

Results

The regression findings in Table 1 indicated a robust correlation between AI adoption and manufacturing efficiency in Nigeria. The coefficient for AI adoption is 0.568, signifying that each unit increase in AI adoption corresponds to an average improvement of 0.568 units in manufacturing efficiency. The association is statistically significant, indicated by a p-value of 0.000, which is below the 0.05 threshold. This discovery corresponds with current research, demonstrating that AI technology may improve operational efficiency via automation and data analytics [8, 9].

Infrastructure significantly contributed to efficiency, evidenced by a coefficient of 0.231 and a p-value of 0.006. This suggests that enhancements in manufacturing infrastructure enhance efficiency, underscoring the need of basic skills for the effective deployment of AI technology [10].

The Workforce Skill coefficient is 0.187, indicating that staff skill levels are essential for the effective use of AI technology. The p-value of 0.045 signifies a strong association, suggesting that investments in workforce development are essential to optimise the advantages of AI adoption [11].

Table 1. Regression Analysis for Efficiency

Variable	Coefficient	Standard Error	t-Statistic	p-Value
AI Adoption	0.568	0.071	8.00	0.000***
Infrastructure	0.231	0.084	2.75	0.006**
Workforce Skill	0.187	0.092	2.03	0.045*
Constant	1.002	0.183	5.47	0.000***

R^2 = 0.759; Adjusted R^2 = 0.749; F-statistic = 75.62; p < 0.0001

Table 2 presents significant findings concerning the influence of AI adoption on productivity in the Nigerian manufacturing sector. The coefficient for AI Adoption is 0.612, signifying a strong positive link between the degree of AI implementation and overall productivity. The importance of this link is shown by a p-value of 0.000, indicating a robust agreement in the literature that AI systems promote productivity improvements via automation and effective resource management [12].

The results underscore the significance of Firm Size, exhibiting a coefficient of 0.314 and a p-value of 0.000. More substantial enterprises are predisposed to possess greater resources for investment in AI technology, resulting in enhanced production. This corresponds with previous research indicating that bigger manufacturing companies are more capable of absorbing the early expenses of AI implementation, hence reaping greater productivity advantages [13].

The coefficient for Industry Type is 0.217, indicating that the sector in which a corporation works affects the productivity enhancements linked to AI technology. Various industries may derive disparate advantages contingent upon their operational attributes and preparedness to embrace innovative technology [14, 15].

The R^2 value of 0.804 indicates that this model accounts for around 80% of the variability in productivity results, underscoring the imperative for factories to implement AI technologies to improve operational efficiency.

Table 2. Regression Analysis for Productivity

Variable	Coefficient	Standard Error	t-Statistic	p-Value
AI Adoption	0.612	0.065	9.42	0.000***
Firm Size	0.314	0.077	4.07	0.000***
Industry Type	0.217	0.095	2.29	0.024*
Constant	0.854	0.177	4.82	0.000***

R^2 = 0.804; Adjusted R^2 = 0.794; F-statistic = 82.01; p < 0.0001

Table 3 illustrates a substantial correlation between AI adoption and product quality in manufacturing processes. The coefficient for AI Adoption is 0.489, signifying that heightened AI use is associated with enhanced product quality. A p-value of 0.000 confirms the statistical significance of this association, consistent with other studies highlighting AI's contribution to improving quality control via real-time monitoring and predictive analytics [16, 17].

Firm size is a significant predictor of product quality, with a coefficient of 0.276 and a p-value of 0.001. This indicates that bigger organisations may possess superior capacities to apply quality-enhancing AI technologies, aligning with research results that show larger

enterprises may spend more substantially in sophisticated quality management systems [18].

The Workforce Skill is similarly significant, with a value of 0.197. This discovery highlights the necessity for ongoing skill enhancement among personnel to proficiently deploy AI systems for quality assurance [19, 20].

An R^2 value of 0.735 signifies that around 74% of the variance in product quality is attributable to the model, underscoring the substantial impact of AI on enhancing product results. This highlights the imperative for manufacturing companies in Nigeria to prioritise the adoption of AI as a strategy to improve product quality.

Table 3. Regression Analysis for Product Quality

Variable	Coefficient	Standard Error	t-Statistic	p-Value
AI Adoption	0.489	0.074	6.61	0.000***
Firm Size	0.276	0.079	3.49	0.001**
Workforce Skill	0.197	0.087	2.26	0.025*
Constant	1.201	0.175	6.86	0.000***

R^2 = 0.735; Adjusted R^2 = 0.724; F-statistic = 69.03; p < 0.0001

Discussion

Statistical Model Used as Below:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \epsilon$$

Where:

Y_i = Manufacturing process optimization (measured by efficiency, productivity, profitability, or product quality)

β_0 = Constant (intercept)

X_1 = AI adoption level (e.g., types of AI technologies implemented)

X_2 = Firm size (control variable)

X_3 = Industry type (control variable)

ϵ = Error term

This study's findings offer significant insights into the influence of AI technology on optimizing manufacturing processes in Nigeria. The investigation utilised regression models to evaluate the correlations between AI adoption and essential manufacturing outcomes—efficiency, productivity, and product quality—resulting in numerous significant results that correspond with the aims stated in the Introduction.

The results highlight the significance of AI implementation as a crucial determinant affecting manufacturing efficiency, productivity, and product quality. The substantial coefficients for AI adoption in all models demonstrate that companies that actively use AI technology achieve large improvements in their operational performance. This directly pertains to the study's primary purpose, affirming that AI adoption is a crucial element in enhancing manufacturing processes.

The findings demonstrate a strong positive link between AI adoption and enhanced efficiency (Table 1), productivity (Table 2), and product quality (Table 3). The models indicate that advancements in these domains are both statistically significant and practically meaningful, implying that AI technologies may substantially improve the performance measures of manufacturing companies. These findings substantiate the second purpose, demonstrating how AI-driven optimisations may enhance profitability by refining processes and elevating output quality.

The study indicates that AI technologies directly boost product quality, as seen by the substantial coefficient for AI adoption in Table 3. This conclusion corresponds with the third purpose of the study, substantiating the premise that the use of AI solutions can enable firms to generate superior quality products, thereby fulfilling consumer expectations and enhancing market competitiveness.

Conclusion

This study has offered significant insights into the influence of Artificial Intelligence (AI) technology on optimizing manufacturing processes in the Nigerian manufacturing sector. The results indicate a robust positive link between AI adoption and improvements in efficiency, productivity, and product quality, thereby achieving the goals specified in the Introduction. The report underscores that the use of AI technology is essential for manufacturing companies aiming to enhance operational performance and maintain competitiveness in a swiftly changing global market.

The substantial coefficients obtained from the regression studies demonstrate that AI technologies are not only an optional addition but a crucial element for attaining operational excellence. Manufacturing companies may optimise processes, decrease operating expenses, and enhance profitability by successfully utilising AI. The results emphasise the necessity of investing in workforce development, since proficient workers are crucial for optimising the advantages of AI integration.

This research enhances the current literature by affirming the beneficial effects of AI technology within the setting of a developing economy, namely Nigeria. The congruence of the findings with prior research highlights the strength and dependability of the results, indicating that AI's revolutionary potential is broadly relevant across many industrial contexts.

This study's ramifications go beyond theoretical contributions, providing practical advice for manufacturing enterprises, politicians, and stakeholders. The survey underscores the necessity for firms to prioritise AI adoption and invest in requisite infrastructure and training to utilise these technologies successfully. Policymakers are encouraged to establish a conducive atmosphere that facilitates AI integration via advantageous rules, financing possibilities, and incentives for technology adoption.

The study indicates the necessity for future research, advocating for sector-specific investigations, longitudinal studies, and qualitative analyses to enhance comprehension of AI's function in manufacturing. By focussing on these aspects, future study can yield more refined insights into the intricacies of AI integration, assisting companies in their strategic decision-making processes.

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Conflict of Interest

There was no conflict of interest as the data was collected from the staff of the sampled manufacturing companies (Dangote Cement Plc and Nigerian Breweries Plc.) hence no financial and time commitment was experienced as this was done during the weekend.

Ethical Approval

The study adhered to ethical guidelines, ensuring that participation was voluntary, and respondents' confidentiality was maintained. All participants were informed of the study's purpose and assured that their responses would only be used for academic purposes. No personal identifiers were collected to ensure anonymity.

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Analgesic Efficacy of Fentanyl and Dexamethasone with Caudal Ropivacaine in Pediatric Infraumbilical Surgeries

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Abstract

Postoperative pain management in paediatric infra-umbilical surgeries remains a challenge. Caudal epidural anaesthesia with Ropivacaine is widely used, but adjuvants such as Fentanyl and Dexamethasone may enhance its analgesic efficacy. This study aimed to compare the analgesic effects of Fentanyl and Dexamethasone as adjuvants to caudal Ropivacaine in paediatric patients undergoing infra-umbilical surgeries. A prospective, randomized, double-blind study was conducted with 54 paediatric patients aged 1-12 years, classified as ASA I or II, undergoing elective infraumbilical surgeries. Patients were randomly divided into two groups: Group F received Ropivacaine (0.25%, 1 ml/kg) with Fentanyl (1 mcg/kg), and Group D received Ropivacaine (0.25%, 1 ml/kg) with Dexamethasone (0.1 mg/kg). Postoperative pain was assessed using the FLACC scale at regular intervals, and the time to first rescue analgesic was recorded. The mean time to first rescue analgesic was significantly longer in Group D (10 hours) compared to Group F (6 hours, $p < 0.001$). FLACC scores were consistently lower in Group D at all measured time points ($p < 0.001$), indicating superior analgesia. Both groups maintained stable hemodynamic parameters, and adverse effects were minimal. Dexamethasone as an adjuvant to caudal Ropivacaine provides prolonged and superior analgesia compared to Fentanyl, making it a more effective option for postoperative pain management in paediatric infra-umbilical surgeries.

Keywords**:** *Caudal Anaesthesia, Dexamethasone, Fentanyl, Paediatric Surgery, Postoperative Pain, Ropivacaine.*

Introduction

Effective postoperative pain management in paediatric patients undergoing infra-umbilical surgeries is essential for improving recovery outcomes and overall patient experience. These surgeries, which include procedures such as hernia repair, orchidopexy, circumcision, and appendectomy, are common in paediatric practice [1]. Managing pain in children presents a unique set of challenges due to their inability to express pain accurately and heightened sensitivity to stress, discomfort, and the potential psychological effects of pain. Inadequate postoperative pain control can lead to delayed recovery, prolonged hospital stays, and potential long-term psychological effects, including an increased risk of chronic pain and heightened pain sensitivity in future medical encounters [2]. Caudal epidural anaesthesia is a widely used technique for paediatric infra-umbilical surgeries due to its ability to provide effective analgesia while reducing the need for systemic opioids and their associated side effects. The caudal block involves the administration of local anaesthetic agents into the epidural space through the sacral hiatus, thereby blocking the nerve impulses in the lower spinal segments. This technique is particularly favoured in paediatric anaesthesia due to the ease of

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administration and the relative safety of the procedure [3].

Ropivacaine, an amide local anaesthetic, is commonly used in paediatric caudal blocks due to its favourable pharmacological properties. Introduced as a safer alternative to bupivacaine, Ropivacaine has a lower risk of cardiotoxicity and neurotoxicity, making it an attractive choice for paediatric anaesthesia. It is a pure S-enantiomer with vasoconstrictive properties that help prolong its duration of action by reducing systemic absorption. Additionally, Ropivacaine provides effective pain relief with minimal motor blockade, which is particularly important for children, as it allows for quicker mobilization post-surgery [5]. Despite these benefits, the use of Ropivacaine alone may not always provide sufficient analgesia for the entire postoperative period. The need to extend the duration of effective analgesia has led to the exploration of various adjuvants that can be added to local anaesthetics to enhance and prolong their effects. Adjuvants such as opioids, alpha-2 adrenergic agonists, and corticosteroids have been studied in combination with local anaesthetics to improve pain control and reduce the requirement for rescue analgesics. Adjuvants are pharmacological agents that, when combined with local anaesthetics, improve the quality and duration of anaesthesia and analgesia. They work through various mechanisms, including modulating pain pathways, reducing inflammatory responses, and providing synergistic effects that enhance the action of local anaesthetics. The use of adjuvants in paediatric caudal anaesthesia has the potential to offer superior pain management while minimizing the dosage of local anaesthetics, thus reducing the risk of associated side effects [6, 7].

Fentanyl is a potent synthetic opioid that is frequently used as an adjuvant in regional anaesthesia due to its strong analgesic properties. It binds to mu-opioid receptors in the central nervous system, inhibiting the transmission of pain signals and producing analgesia. Fentanyl's lipophilic nature facilitates rapid onset and prolonged duration of action, making it a valuable addition to local anaesthetics. Previous studies have demonstrated that adding Fentanyl to caudal Ropivacaine can significantly extend the duration of analgesia without causing major adverse effects. However, the use of opioids, including Fentanyl, is not without risks. While caudal administration of Fentanyl is associated with fewer systemic side effects than intravenous administration, it still carries the risk of opioid-related complications such as respiratory depression, pruritus, and nausea. Therefore, the search for alternative adjuvants that can provide prolonged analgesia without the associated opioid risks has gained momentum in recent years [7, 8].

Dexamethasone, a potent corticosteroid, has gained attention as an adjuvant in regional anesthesia due to its anti-inflammatory and immunosuppressive properties. It is hypothesized that Dexamethasone prolongs the duration of analgesia by reducing local inflammation and modulating nociceptive pathways. Its mechanism of action includes inhibiting the release of pro-inflammatory mediators such as prostaglandins and cytokines, thereby reducing pain and inflammation at the site of the nerve block. Studies have shown that adding Dexamethasone to local anaesthetics can significantly extend the duration of analgesia without increasing adverse effects. In paediatric patients, the use of Dexamethasone as an adjuvant to caudal blocks is particularly appealing due to its ability to provide prolonged pain relief without the opioid-related side effects seen with Fentanyl. Dexamethasone has been shown to reduce the need for rescue analgesics, improve patient comfort, and facilitate earlier discharge from the hospital [7, 9].

Given the challenges associated with managing postoperative pain in paediatric

patients and the potential benefits of using adjuvants to enhance caudal anaesthesia, this study aims to compare the analgesic efficacy of Fentanyl and Dexamethasone as adjuvants to caudal Ropivacaine in paediatric infra-umbilical surgeries. Although both Fentanyl and Dexamethasone have been studied individually as adjuvants, there is limited data directly comparing their efficacy in a paediatric population. Understanding which adjuvant provides more effective and longer-lasting analgesia can help optimize pain management protocols in paediatric anaesthesia. The primary objective of this study is to compare the duration of effective analgesia provided by caudal Ropivacaine when combined with either Fentanyl or Dexamethasone in paediatric infra-umbilical surgeries. The study also aims to assess postoperative pain scores using the FLACC (Face, Legs, Activity, Cry, Consolability) scale [10] at regular intervals during the first 12 hours post-surgery. In addition, the time to first rescue analgesic and hemodynamic stability, as well as the incidence of any adverse effects, will be evaluated to determine the safety profiles of the two adjuvants. Effective pain management in paediatric surgery not only improves patient comfort but also plays a crucial role in reducing surgical stress, improving wound healing, and preventing long-term psychological consequences. This study's findings are expected to contribute to the growing body of knowledge on optimizing paediatric postoperative pain management, particularly in the use of adjuvants to caudal Ropivacaine. By comparing Fentanyl and Dexamethasone, this study seeks to identify the more effective adjuvant in terms of prolonging analgesia, minimizing opioid-related side effects, and ensuring hemodynamic stability.

Materials and Methods

Study Design

This was a prospective, randomized, double-blind, parallel-group study designed to compare the analgesic efficacy and safety of Fentanyl and Dexamethasone as adjuvants to caudal Ropivacaine in paediatric patients undergoing infra-umbilical surgeries. The study was conducted at the Department of Anaesthesiology, Sree Balaji Medical College and Hospital, Bharath University, Chennai. Ethical approval was obtained from the institutional review board, and informed consent was obtained from the parents or guardians of all participating patients.

Study Population

The study enrolled paediatric patients aged between 1 and 12 years who were scheduled to undergo elective infraumbilical surgeries, including procedures such as hernia repair, orchidopexy, circumcision, and hypospadias repair. Patients were classified as American Society of Anaesthesiologists (ASA) physical status I or II. Patients were excluded if they had a known hypersensitivity to local anaesthetics or study drugs, coagulopathy, infection at the site of caudal injection, neurological disorders, psychiatric illness, or if their parents refused consent.

Inclusion Criteria

Paediatric patients aged between 1 and 12 years who were scheduled for elective infraumbilical surgeries, such as hernia repair, orchidopexy, circumcision, or hypospadias repair, were eligible for the study. Patients were required to have an American Society of Anaesthesiologists (ASA) physical status classification of I or II, indicating that they were generally healthy or had only mild systemic disease. Additionally, written informed consent had to be obtained from the patient’s parents or legal guardians before the procedure. All patients were expected to

undergo general anaesthesia with a caudal block for postoperative pain management.

Exclusion Criteria

Patients were excluded from the study if they had an ASA classification of III or IV, indicating severe systemic disease or a life-threatening condition. Other exclusion criteria included patients undergoing emergency surgeries, known allergies to local anaesthetics, Fentanyl, or Dexamethasone, and those with coagulopathy or anticoagulant use. Patients with infections at the site of the caudal block, pre-existing neurological disorders, or psychiatric illness were also excluded. Additionally, any patient whose parents or legal guardians refused to provide informed consent was not enrolled in the study, ensuring ethical compliance.

Sample Size

A sample size of 54 patients was calculated based on a power analysis using data from a similar study by Gandhi et al. (2021), which compared the effects of adjuvants on caudal anaesthesia. The analysis determined that 27 patients per group would provide an 80% power to detect a statistically significant difference in postoperative pain scores (FLACC scores) between the two groups, with a confidence level of 95% and an alpha error of 0.05.

Randomization and Blinding

Patients were randomly assigned into two groups using a computer-generated randomization table. Group F received Ropivacaine (0.25%, 1 ml/kg) with Fentanyl (1 mcg/kg), while Group D received Ropivacaine (0.25%, 1 ml/kg) with Dexamethasone (0.1 mg/kg). Randomization was performed by an independent researcher who was not involved in patient care. The anaesthesiologist performing the caudal block, the patient, and the researcher responsible for postoperative assessments were all blinded to the group allocation. The study drugs were prepared in identical syringes by an independent anaesthesiologist who was not involved in data collection or patient care.

Anaesthesia Protocol

All patients underwent a standard preoperative assessment, including a thorough medical history, physical examination, and routine laboratory investigations. On the day of surgery, patients were kept nil per oral (NPO) for 6 hours for solids, 4 hours for breast milk, and 2 hours for clear liquids. In the operating room, standard monitoring devices were applied, including non-invasive blood pressure (NIBP), pulse oximetry (SpO2), and electrocardiography (ECG). Baseline heart rate, blood pressure, and oxygen saturation were recorded. All patients received premedication with intravenous glycopyrrolate (0.004 mg/kg) and midazolam (0.01 mg/kg) to reduce anxiety and secretions. General anaesthesia was induced with intravenous propofol (2–3 mg/kg) and Fentanyl (2–3 mcg/kg), followed by muscle relaxation with atracurium (0.5 mg/kg). After adequate mask ventilation, either a laryngeal mask airway (LMA) or an endotracheal tube was inserted. Anaesthesia was maintained with oxygen, nitrous oxide, and sevoflurane (1–2%).

Caudal Block Technique

Following induction of general anaesthesia, the patient was placed in the left lateral decubitus position. Under sterile conditions, the caudal epidural space was identified using anatomical landmarks, specifically the sacral hiatus and sacral cornua. A 22-gauge hypodermic needle was advanced through the sacrococcygeal ligament into the caudal epidural space. After negative aspiration for blood or cerebrospinal fluid (CSF), 0.25% Ropivacaine (1 ml/kg) with either Fentanyl (1 mcg/kg) or Dexamethasone (0.1 mg/kg) was administered slowly over 1–2 minutes. The correct placement of the needle was confirmed using the "whoosh" test, in which the injection

of air produced an audible sound as it entered the epidural space. Intraoperatively, heart rate, blood pressure, respiratory rate, end-tidal CO2 (ETCO2), and SpO2 were continuously monitored. At the end of the procedure, neuromuscular blockade was reversed with intravenous neostigmine (0.05 mg/kg) and glycopyrrolate (0.01 mg/kg). Patients were extubated when fully awake and transferred to the post-anaesthesia care unit (PACU) for further monitoring.

Postoperative Pain Assessment

Postoperative pain was assessed using the FLACC (Face, Legs, Activity, Cry, Consolability) scale, which is widely used for evaluating pain in children who cannot verbalize their pain levels. The FLACC scale assigns a score of 0 to 2 for each category, with a total score ranging from 0 to 10. A score of 0–3 indicates mild pain, 4–7 indicates moderate pain, and 8–10 indicates severe pain. Pain assessments were conducted at 1-hour intervals for the first 3 hours, followed by assessments every 2 hours for the next 12 hours. The primary outcome measure was the duration of effective analgesia, defined as the time from caudal block administration to the first requirement of rescue analgesia. Rescue analgesia, in the form of intravenous paracetamol (15 mg/kg), was administered if the FLACC score exceeded 4 at any time point.

Secondary Outcome Measures

The secondary outcome measures included evaluating postoperative hemodynamic stability by monitoring heart rate and blood pressure at regular intervals. The study also assessed the incidence of adverse effects such as respiratory depression, nausea, vomiting, pruritus, and urinary retention, which are common complications of opioid and corticosteroid use. The proportion of patients requiring rescue analgesia during the 12-hour postoperative period was recorded, providing insights into the duration and quality of analgesia in both groups. These outcomes helped determine the safety profile and overall effectiveness of Fentanyl and Dexamethasone as adjuvants to caudal Ropivacaine.

Statistical Analysis

Descriptive statistics were used to summarize patient demographics and baseline characteristics. Continuous variables, such as age, weight, and duration of analgesia, were expressed as mean ± standard deviation (SD) and compared between the two groups using an independent t-test. Categorical variables, such as gender distribution and the proportion of patients requiring rescue analgesia, were compared using the chi-square test or Fisher's exact test as appropriate. Pain scores (FLACC scores) were analysed at each time point using repeated measures ANOVA to account for within-subject correlations. Kaplan-Meier survival analysis was performed to compare the time to first rescue analgesic between the two groups, and the log-rank test was used to assess statistical significance. Hemodynamic data, including heart rate and blood pressure, were analysed using repeated measures ANOVA to evaluate changes over time between the two groups. Adverse events were compared using chi-square or Fisher's exact tests. All statistical analyses were conducted using SPSS version 22.0 (IBM Corp., Armonk, NY), and a p-value of < 0.05 was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with the ethical guidelines of the Declaration of Helsinki and Good Clinical Practice (GCP) standards. Ethical approval was obtained from the institutional ethics committee prior to the commencement of the study. Written informed consent was obtained from the parents or legal guardians of all patients before enrolment in the study.

Results

A total of 54 paediatric patients undergoing infra-umbilical surgeries were enrolled in the study and randomly assigned into two groups: Group F (Ropivacaine with Fentanyl, n=27) and Group D (Ropivacaine with Dexamethasone, n=27). The demographic characteristics of the two groups were comparable, with no statistically significant differences. The mean age in Group F was 5.2 ± 1.8 years, while in Group D, it was 5.4 ± 1.9 years ($p = 0.70$) (Figure 1a). The gender distribution was balanced in both groups, with 51.8% males in Group F and 55.5% males in Group D ($p = 0.60$) (Figure 1b). The mean weight was 18.3 ± 3.2 kg in Group F and 18.7 ± 3.1 kg in Group D ($p = 0.65$), showing no significant difference in body weight (Figure 1c). Both groups had a comparable ASA classification, with 74.1% of patients in Group F and 81.5% in Group D classified as ASA I ($p = 0.55$) (Figure 1d).

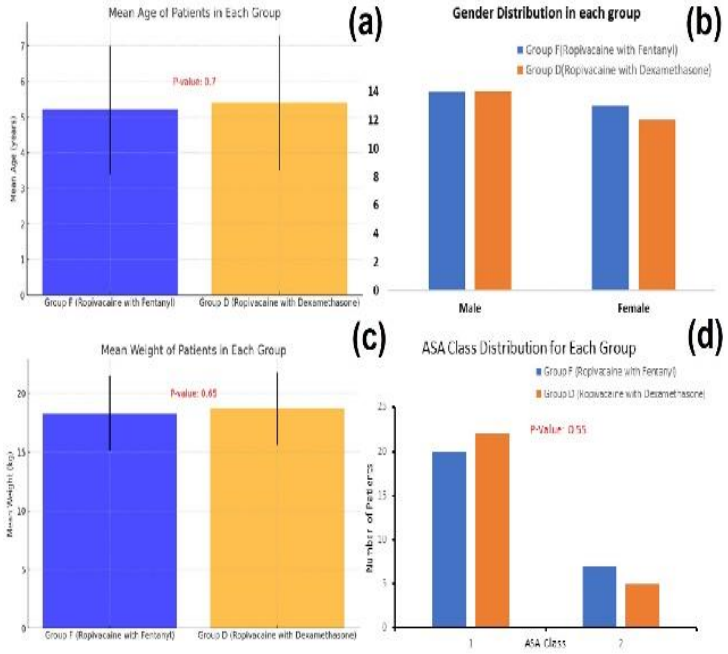

Figure 1. a) Mean Age, b) Gender Distribution, c) Mean weight, d) ASA Class

Postoperative pain was assessed using the FLACC scale at 1-hour intervals for the first 3 hours, and then at 2-hour intervals until 12 hours postoperatively. FLACC scores were significantly lower in Group D (Ropivacaine + Dexamethasone) compared to Group F (Ropivacaine + Fentanyl) at all time points. At 1 hour, Group F had a mean FLACC score of 2.5 ± 1.0, while Group D had a significantly lower score of 1.0 ± 0.5 ($p < 0.001$). At 2 hours, the mean FLACC score in Group F increased to 3.0 ± 1.2, whereas it remained low in Group D at 1.2 ± 0.6 ($p < 0.001$). At 4 hours, Group F's FLACC score rose to 4.0 ± 1.8, compared to 1.8 ± 0.9 in Group D ($p < 0.001$). At 6 hours, Group F's mean FLACC score was 4.5 ± 2.0, while Group D had a significantly lower score of 2.0 ± 1.0 ($p < 0.001$). At 12 hours, the final FLACC scores were 5.0 ± 2.5 in Group F and 3.0 ± 1.2 in Group D ($p < 0.001$) (Figure 2). The results demonstrate consistently lower pain scores in the Dexamethasone group, indicating more effective postoperative pain control compared to the Fentanyl group.

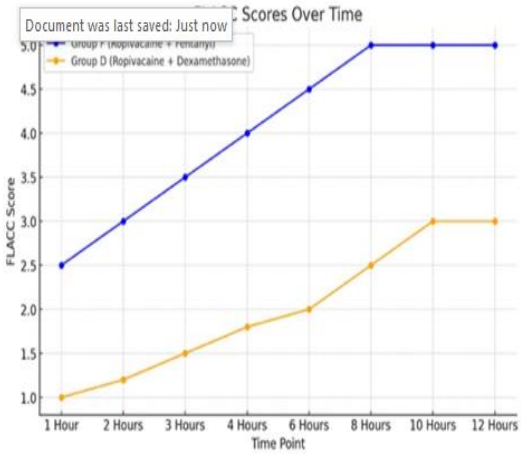

Figure 2. FLACC Scores at Different Time Points

The mean time to first rescue analgesic was significantly longer in Group D (Ropivacaine + Dexamethasone) compared to Group F (Ropivacaine + Fentanyl). In Group F, the mean time to the first administration of rescue analgesia (intravenous paracetamol) was 6 hours (95% CI: 5.5–6.5), whereas in Group D, the mean time was 10 hours (95% CI: 9.5–10.5) ($p < 0.001$) (Figure 3). This indicates that patients in the Dexamethasone group experienced longer-lasting analgesia compared to those in the Fentanyl group. A Kaplan-Meier survival analysis was conducted to compare the time to first rescue analgesic between the two groups, with the log-rank test showing a statistically significant difference favoring Group D ($p < 0.001$). The prolonged duration of analgesia in Group D suggests that Dexamethasone is a more effective adjuvant for extending the analgesic effects of caudal Ropivacaine.

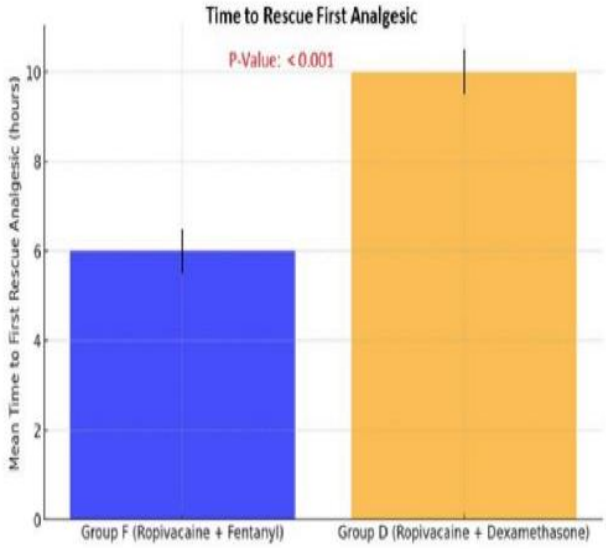

Figure 3. Time to first Rescue Analgesic in both the Groups

Both groups maintained stable hemodynamic parameters throughout the postoperative period. No significant differences were observed in heart rate or blood pressure between Group F and Group D at any time point. At 1 hour postoperatively, the mean heart rate was 105 ± 10 bpm in Group F and 106 ± 9 bpm in Group D ($p = 0.876$). At 4 hours, the heart rates were 102 ± 10 bpm in Group F and 103 ± 9 bpm in Group

D (p = 0.235). At 12 hours, the heart rates remained comparable, with 100 ± 10 bpm in Group F and 101 ± 9 bpm in Group D (p = 0.876) (Figure 4a). Similarly, blood pressure measurements were stable in both groups, with no significant differences. At 1 hour postoperatively, the mean blood pressure was 85/55 mmHg in Group F and 87/57 mmHg in Group D (p = 0.287). At 4 hours, the blood pressure was 82/52 mmHg in Group F and 84/54 mmHg in Group D (p = 0.295). At 12 hours, both groups showed similar readings of 80/50 mmHg in Group F and 82/52 mmHg in Group D (p = 0.806) (Figure 4b and 4c). These findings suggest that both Fentanyl and Dexamethasone maintained stable cardiovascular profiles when used as adjuvants to caudal Ropivacaine.

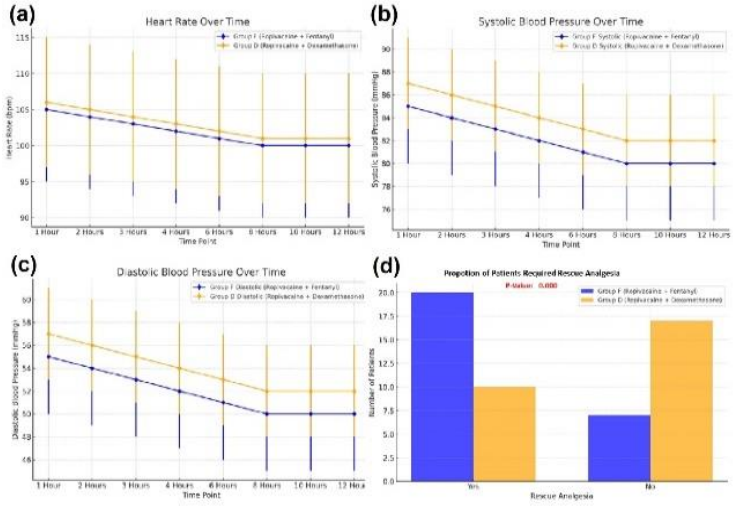

Figure 4. a) Comparison of Heart Rate, b) Comparison of Systolic Blood Pressure, c) Comparison of Diastolic Blood Pressure, d) Proportion of Patients Requiring Rescue Analgesia

The incidence of adverse effects was minimal in both groups, with no major complications reported. However, Group F (Ropivacaine + Fentanyl) had a higher occurrence of minor side effects compared to Group D (Ropivacaine + Dexamethasone). In Group F, 3 patients (11.1%) experienced pruritus, 2 patients (7.4%) had nausea, and 1 patient (3.7%) reported vomiting. In Group D, no cases of pruritus, nausea, or vomiting were reported. Respiratory depression was not observed in either group, or there were no cases of urinary retention. The difference in the incidence of adverse effects between the two groups was not statistically significant, but the absence of side effects in the Dexamethasone group further supports its favourable safety profile. The proportion of patients requiring rescue analgesia during the 12-hour postoperative period was significantly higher in Group F (Ropivacaine + Fentanyl) compared to Group D (Ropivacaine + Dexamethasone). In Group F, 20 out of 27 patients (74.1%) required rescue analgesia, while only 10 out of 27 patients (37.0%) in Group D needed additional analgesia (p < 0.001) (Figure 4d). This further emphasizes the superior analgesic efficacy of Dexamethasone when used as an adjuvant to Ropivacaine in caudal blocks.

Discussion

Postoperative pain management in paediatric patients undergoing infra-umbilical surgeries presents a significant challenge due to the patients' limited ability to express pain and the potential for both short- and long-term physiological and psychological consequences if pain is inadequately treated. Caudal epidural anaesthesia, particularly with Ropivacaine, is a well-established technique for providing effective intraoperative and postoperative analgesia in paediatric patients. However, the

duration of analgesia provided by Ropivacaine alone is often insufficient to cover the entire postoperative period, necessitating the use of adjuvants to prolong its effects [11, 12, 13]. This study compared the analgesic efficacy and safety of two adjuvants, Fentanyl and Dexamethasone, when added to caudal Ropivacaine in paediatric infra-umbilical surgeries. The results demonstrate a clear advantage of Dexamethasone over Fentanyl in terms of prolonged analgesia, lower postoperative pain scores, and fewer rescue analgesia requirements.

The primary outcome of this study was the duration of effective analgesia, measured as the time to first rescue analgesic. The findings clearly showed that Dexamethasone provided a significantly longer duration of analgesia compared to Fentanyl. In Group D (Ropivacaine + Dexamethasone), the mean time to first rescue analgesic was 10 hours, compared to 6 hours in Group F (Ropivacaine + Fentanyl) ($p < 0.001$). This difference is clinically significant, as it indicates that patients in the Dexamethasone group experienced prolonged pain relief, reducing the need for additional analgesics during the immediate postoperative period. The mechanism by which Dexamethasone prolongs analgesia is likely multifactorial. As a potent anti-inflammatory corticosteroid, Dexamethasone reduces local inflammation at the site of nerve blockade, which can enhance the effect of local anaesthetics. It also modulates nociceptive pathways, potentially stabilizing nerve membranes and reducing pain transmission. These actions contribute to the sustained analgesic effects observed in the Dexamethasone group. The findings align with previous studies that have demonstrated the analgesic benefits of Dexamethasone when used as an adjuvant in various regional anaesthesia techniques, including caudal blocks [14, 15, 16, 17].

In contrast, while Fentanyl also enhanced the duration of analgesia compared to Ropivacaine alone, its effects were notably shorter than those of Dexamethasone. Fentanyl, as a synthetic opioid, works by binding to mu-opioid receptors, providing potent analgesia. However, the relatively short half-life of Fentanyl may account for the earlier requirement of rescue analgesics in Group F. The opioid effects of Fentanyl also raise concerns about potential side effects, although the incidence of such effects was low in this study [18, 19, 20, 21].

The FLACC pain score, used to assess postoperative pain in non-verbal pediatric patients, revealed significantly lower scores in the Dexamethasone group at all postoperative time points. The FLACC scores in Group D remained below 2 for the first 6 hours postoperatively, compared to significantly higher scores in Group F during the same period. At 12 hours postoperatively, Group F had a mean FLACC score of 5.0 ± 2.5, while Group D maintained a lower score of 3.0 ± 1.2 ($p < 0.001$). These lower pain scores in Group D reflect the superior analgesic efficacy of Dexamethasone, which likely stems from its anti-inflammatory properties and its ability to reduce local tissue irritation. By preventing the release of pro-inflammatory cytokines and reducing peripheral sensitization, Dexamethasone minimizes the perception of pain. The sustained low pain scores in the Dexamethasone group support its use as a highly effective adjuvant in paediatric caudal blocks [22, 23, 24].

Both Fentanyl and Dexamethasone maintained stable hemodynamic parameters in the postoperative period. There were no significant differences in heart rate or blood pressure between the two groups at any time point, and all patients remained hemodynamically stable throughout the study. These findings are important, as they demonstrate that both adjuvants can be used safely in paediatric patients without causing significant cardiovascular fluctuations. While Fentanyl is known to cause bradycardia and

hypotension in some cases, the low doses used in this study were well-tolerated by the patients. Similarly, Dexamethasone has a favourable safety profile and did not induce any significant hemodynamic changes. The incidence of adverse effects was minimal in both groups, though Fentanyl was associated with a slightly higher occurrence of side effects. In Group F, 11.1% of patients experienced pruritus, and 7.4% reported nausea. These are common side effects of opioids and can be distressing for pediatric patients. In contrast, no patients in Group D reported pruritus, nausea, or vomiting, further emphasizing the safety of Dexamethasone as an adjuvant. Respiratory depression, a major concern with opioid use, was not observed in any patients, likely due to the low dose of Fentanyl administered. However, the potential for respiratory complications remains a significant consideration when using opioids in paediatric patients. Dexamethasone, on the other hand, did not cause any opioid-related side effects, and its anti-inflammatory properties may have contributed to a smoother postoperative recovery with fewer complications. These findings suggest that Dexamethasone may be the preferable adjuvant in paediatric caudal blocks, offering both superior analgesia and a lower incidence of side effects.

The findings of this study are consistent with previous research comparing the analgesic effects of Fentanyl and Dexamethasone as adjuvants to local anaesthetics. Studies have shown that Dexamethasone, when used in caudal blocks, significantly prolongs the duration of analgesia without major side effects. For example, a study by Kim et al. (2014) [9] demonstrated that Dexamethasone provided prolonged postoperative pain relief in paediatric patients undergoing orchidopexy, with a duration of analgesia similar to that observed in the present study. Similarly, other studies have reported that Fentanyl enhances the duration of analgesia when used with caudal Ropivacaine but is associated with a higher incidence of opioid-related side effects. This study's findings align with those results, further supporting the use of Dexamethasone as the superior adjuvant for prolonging analgesia and minimizing side effects.

The results of this study have important clinical implications for paediatric anaesthesiologists. Effective postoperative pain management in paediatric patients is critical for improving recovery outcomes, reducing stress responses, and preventing long-term psychological consequences. The findings suggest that Dexamethasone should be considered the preferred adjuvant to caudal Ropivacaine in paediatric infra-umbilical surgeries, as it provides longer-lasting analgesia with fewer side effects than Fentanyl. The use of Dexamethasone could lead to improved patient comfort, reduced need for rescue analgesics, and shorter hospital stays, all of which contribute to better overall recovery. Furthermore, the lower incidence of side effects associated with Dexamethasone makes it a safer option, particularly in paediatric patients, who are more vulnerable to opioid-related complications. These benefits highlight the value of incorporating Dexamethasone into standard pain management protocols for paediatric infra-umbilical surgeries.

While this study provides valuable insights into the analgesic efficacy of Fentanyl and Dexamethasone, there are some limitations to consider. The relatively small sample size may limit the generalizability of the findings, and the study was conducted at a single center, which could introduce bias related to local practices. Additionally, the study focused on short-term outcomes, with follow-up limited to the first 12 hours postoperatively. Future research should include larger, multicenter trials with longer follow-up periods to assess the long-term safety and efficacy of these adjuvants.

Conclusion

This study demonstrates that Dexamethasone is a more effective and safer adjuvant than Fentanyl when used with caudal Ropivacaine in paediatric infra-umbilical surgeries. Dexamethasone provided significantly longer analgesia, lower postoperative pain scores, and fewer rescue analgesia requirements than Fentanyl. It also had a more favourable safety profile, with fewer opioid-related side effects. These findings support the use of Dexamethasone as an ideal adjuvant in paediatric caudal anaesthesia for infra-umbilical surgeries.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Childhood Knee Problem as a Risk Factor for Adulthood Knee Osteoarthritis: A Case-Control Study

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Abstract

Knee osteoarthritis (OA) is the most common joint affected with osteoarthritis. It has multifactorial causative factors including childhood knee problems and disorders. The study aimed to investigate childhood-specific knee problems as risk factors for knee Osteoarthritis in adulthood. This case-control study was conducted at an Orthopaedic Hospital Wamakko, Sokoto, North-Western Nigeria between January 2022 and December 2022. Cases with knee OA were diagnosed using the American College of Rheumatology (ACR) criteria which include knee pain with at least three out of six criteria in the case group. The inclusion criteria were adult patients aged >40 years with knee OA. The data collected was analysed using SPSS version 26. There were a total of 372 patients in the study with 124 cases and 248 controls in a ratio of 1:2. The average age was 53.7±10.8 (range 40 to 88 years). There were 165 (44.4%) males and 207 (55.6%) females. Among all the patients, there were 15 (4.03%) patients with previous childhood knee problems and 357 (95.97%) no history of previous childhood knee problems. Among the cases group, there were 13 (10.5%) cases with previous childhood knee problems and among them, there were 8 males and 7 females; childhood history of injury (6), patella instability (3), unspecific knee pains (2), peri-articular fracture (1), and knee infection (1). There was a statistically significant result between childhood knee problems and Adulthood knee OA (OR=14.405, CI=3.197-64.915, and P<0.001). The study findings have shown childhood knee problems to be risk factors for adulthood knee osteoarthritis.

Keywords**:** *Childhood Knee Problems, Case-Control Study, Knee Injuries, Knee Osteoarthritis.*

Introduction

Osteoarthritis (OA) is a chronic non-communicable disease presenting with pain and joint stiffness that result from the gradual loss of articular cartilage and other structural damage [1]. It affects the whole joint with subsequent loss of function, disability and reduced overall quality-adjusted life years (DALYs). The OA global prevalence of 16% is a concern to the socio-economic and job-related performance [2]. Among the OA diseases, Knee osteoarthritis (OA) is the most common and is equally associated with chronic and discomforting symptoms that may warrant total joint replacement [3]. Knee OA has multifactorial causative factors and most importantly are age, female gender, genetic predisposition, increased body weight and obesity, occupation, and previous knee injury among others [2, 4]. Of particular importance is the predisposing factor for risk of knee OA

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during childhood because problems or disorders that arose during the young age period may contribute to the pathogenesis of knee OA during adulthood [5, 6]. These knee disorders include knee trauma, congenital and developmental diseases like Blount disease, metabolic bone disorders, patella instability, and knee ligament injuries. With the need for more research that produces innovative and cost-effective methods of preventing or slowing down the advancement of knee OA, identifying and dealing with these factors, particularly at a young age is crucial to the public health approach in the management of knee OA [7]. As knee OA is largely a disease of the older population, the influence of early age factors in its aetiology could not be underestimated because of the chronicity and disease course before its clinical manifestation. This caused some difficulties in conducting longitudinal research relating early age factors in causing old age osteoarthritis due to a need for long-term follow-up and challenges in identifying the early factors [5, 8]. With these background facts, only a few studies are now available relating childhood knee problems with adulthood knee OA.

The study's aim was to investigate childhood-specific knee problems as risk factors for knee Osteoarthritis in adulthood by conducting a hospital-based case-control study.

Materials and Methods

This case-control study was conducted at a major Orthopaedic referral Hospital, Wamakko, located in Sokoto, North-Western Nigeria for a period between January 2022 and December 2022. The study was conducted following ethical approval from the Ministry of Health Sokoto with Ref no. SMH/1580/V.IV. The cases with knee OA and unmatched controls were randomly selected during the clinic visits within the study period. Cases with knee OA were diagnosed using the American College of Rheumatology (ACR) criteria which include knee pain with at least three out of six criteria in the case group [9]. The inclusion criteria were adult patients aged >40 years with knee OA, and the exclusion criteria were knee infection, post-peri-articular fracture and postoperative knees. The data collection was made via participants' interviews with the use of a reliable questionnaire. Questions regarding demographic features, childhood knee problems and other associated risk factors for knee OA were asked. This was followed by Knee joint clinical presentations and detail of radiological findings. The knee clinical examination focussed on the evidence of knee deformity and previous scar.

Data were analysed using SPSS version 26 and categorical variables were presented in form of frequency and percentages. Initially, univariate analysis was used to compute p-values through chi-square for the categorical variables and student t-test for the numerical variables. Then multivariate logistic regression model was used to assess the association between the various risk factors and knee OA. The independent association with the risk of the knee was considered positive if the exposure variables were significant at a 5% level.

Results

Tables 1 to 3 showed some important aspects of the results. There were a total of 372 patients in the study with 124 cases and 248 controls in a ratio of 1:2. The average age was 53.7±10.8 (range 40 to 88 years). There were 165 (44.4%) males and 207 (55.6%) females. Among all the patients, there were 15 (4.03%) patients with previous childhood knee problems and 357 (95.97%) with no history of previous childhood knee problems. Among the cases group, there were 13 (10.5%) cases with previous childhood knee problems and among them, there was a childhood history of injury (6), patella instability (3), unspecific knee pains (2), peri-articular fracture (1), and knee

infection (1) (Figure 1). There were 8 men and 7 females with childhood knee problems in the study.

There was a statistically significance result between childhood knee problems and Adulthood knee OA (OR=14.405, CI=3.197-64.915, and P<0.001) (Table 2). Table 3 provides results for logistics regression of all factors taken into consideration in this study, and for the childhood knee problems, the OR=9.474 (CI=2.560-69.115; p<0.002).

Table 1. Socio-Demographic Characteristics of Respondents

Variable	**Patient category n (%)**		
	Case	**Control**	**Total**
Age (in years)			
40.00 - 49.00	50(35.2)	92(64.8)	142(100.0)
50.00 - 59.00	41(35.3)	75(64.7)	116(100.0)
60.00 - 69.00	20(27)	54(73)	74(100.0)
70.00 - 79.00	8(25.8)	23(74.2)	31(100.0)
80.00+	5(55.6)	4(44.4)	9(2.100.0)
Gender			
Male	49(29.7)	116(70.3)	165(100.0)
Female	75(36.2)	132(63.8)	207(100.0)
Ethnic group			
Hausa Fulani	116(33.2)	233(66.8)	349(100.0)
Others	8(34.8)	15(65.2)	23(100.0)
Occupation			
No occupation	63(31.3)	138(68.7)	201(100.0)
Business	26(43.3)	34(56.7)	60(100.0)
Civil servant	19(31.1)	42(68.9)	61(100.0)
Farmer	16(32)	34(68)	50(100.0)
Education			
Non-Formal education	89(35.6)	161(64.4)	250(100.0)
Formal education	35(28.7)	87(71.3)	122(100.0)
Marital Status			
Married	104(31.9)	222(68.1)	326(100.0)
Single	17(42.5)	23(57.5)	40(100.0)
Divorced/widowed	3(50)	3(50)	6(100.0)

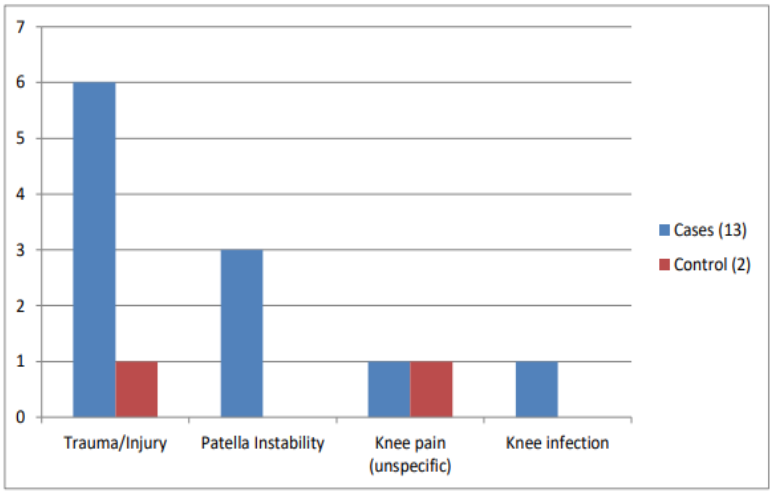

Figure 1. Various Childhood Problems in both Cases and Controls

Table 2. Risk Estimate

	Value	**95% Confidence Interval**	
		Lower	**Upper**
Odds Ratio for Childhood knee problem (Yes / No)	14.405	3.197	64.915
For cohort Patient Category = Case	2.787	2.168	3.584
For cohort Patient Category = 2.00	.193	.053	.704
N of Valid Cases	372		

Table 3. Potential risk factors related to knee OA (Logistic regression results)

Independent Variables		**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**	**95% C.I.for EXP(B)**	
								Lower	**Upper**
Step 1[a]	Childhood Knee Problems	2.588	.841	9.474	1	.002	13.301	2.560	69.115
	Age (Years)	-.004	.012	.103	1	.749	.996	.973	1.020
	Gender	-.633	.284	4.962	1	.026	.531	.304	.927
	Smoking	.619	.509	1.481	1	.224	1.857	.685	5.034
	Alcohol	-19.975	22109.226	.000	1	.999	.000	.000	.
	Exercise	1.497	.416	12.985	1	.000	4.470	1.980	10.092
	Education	.064	.290	.049	1	.824	1.067	.604	1.884
	Family History Knee OA	-1.919	.494	15.058	1	.000	.147	.056	.387
	Obesity	1.775	.271	42.773	1	.000	5.899	3.466	10.040
	Constant	.546	.850	.412	1	.521	1.726		

Discussion

The risk of developing Knee OA is multifactorial and these include modifiable and non-modifiable risk factors [10]. Among the latter group, childhood knee problems present various modifiable and preventable risk factors because preventing or treating such disorders at an early age can greatly reduce the prevalence of knee OA and Knee OA-related morbidities during adulthood [11]. This study presented 13 (10.5%) patients with childhood knee problems among the 124 knee OA cases. The knee problems recorded include knee trauma, patella instability, unspecific knee pain, peri-articular fracture and knee joint infections.

Children and young adults are known to be involved in both indoor and outdoor play [12]. The frequent involvement in school physical activities exposed them to easy sustainability to physical injuries that comprised knee ligaments and meniscal tear, simple strains and sprains, Osgood Schlatter disease (OSD), fracture around the knee and knee dislocations [13]. Other childhood problems including mal-alignment disorders like Blount disease, infections such as septic arthritis and osteomyelitis, and unspecific anterior knee pain especially the one arising from Osteochondritis dessican (OCD) and bursitis all contribute as predisposing factors for adulthood knee OA [14].

The current study did not take other childhood factors like obesity, socioeconomic factors, and child abuse into consideration. Other studies considered multiple factors but have acknowledged the challenge of measuring the long-term effects of childhood factors on knee OA [5, 15]. While research by Snoeker B et al explicitly looked at different types of knee injuries sustained by young adults in a population-based cohort study reported 6 times the risk of future knee OA with the highest risk associated with cruciate ligament injury, meniscal tear and intra-articular fractures [16]. Recurrent patella dislocation that occurs commonly at a young age has been linked with the risk of adulthood knee OA specifically the patella-femoral osteoarthritis (PFOA). A case-control study to determine the effect of adolescent knee pain and patella dislocation on adulthood PFOA reported that young patients with anterior knee pain are 7.5 times more likely to have patella dislocation and this has a strong risk for knee OA later in life [17]. Peri-articular and intra-articular fractures occurring at an early age serve as a major risk factor for adulthood knee OA due to early articular cartilage biomechanical damage and prolonged wear and tear from knee joint mal-alignments [12, 18].

Childhood knee septic arthritis if not diagnosed early and promptly treated could lead to accelerated cartilage breakdown with subsequent predisposition to various joint complications including adulthood knee OA [19]. It may be difficult to ascertain this diagnosis in retrospect by patients who are affected by knee OA in adulthood. However, a history of febrile illness, joint pain and swelling may provide useful hints on the likelihood of joint infection as being the offending factor. Many joints, post-septic arthritis were likely ankylosed or if treated early may have undergone one of the knee joint procedures including knee arthroplasty [20].

The limitations of the study include a lack of consideration for other childhood knee problems as risk factors for knee OA later in life such as obesity and other socioeconomic factors, and this may have contributed to the lower positive response among the study subjects. The facts that recall bias exists especially on the knee problems that were completely treated or the problems went unnoticed were there to be factored in. However, the use of specific knee factors such as trauma, patella dislocation and infections have narrowed down the question and findings to be easily evaluated and validly reported.

Conclusion

These study findings have shown that childhood knee problems such as knee injuries, and patella instability are independent risk factors for adulthood knee osteoarthritis. Prevention and early treatment of these problems may remarkably reduce the current high prevalence of knee OA in adulthood.

Competing Interests

The author declared no known competing interests

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Assessment of Tuberculosis Awareness and Perspectives among the Working Population Across Lagos State

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Abstract

Tuberculosis (TB) continues to be an important public health concern in Lagos, Nigeria, as it accounts for 11% of this burden in Nigeria. A cross-sectional study design was employed. Socio-demographic data (age, gender, highest level of education, local government area, and employment status) from deidentified persons who gave consent were investigated using a structured and pretested questionnaire in a Google Form. 310 participants met the inclusion criteria of working and living in Lagos State. In this study, 96.5% of the participants have heard of TB before; only 36.5% knew what TB is called in their local dialect; 75.8% know TB is caused by a microorganism; 83.2% know the signs and symptoms of TB; 91.6% of the participants know the contagiousness of TB; 91.9% admitted that importance of the knowledge of TB endemicity in Nigeria; 66% learnt about TB in school; 45.2% of the participants have ever been screened for TB; 9.7% implied they have TB associated stigma behaviour; 67.7% of participants knew at least one method of TB diagnosis; only 2.9% among the participants has been diagnosed of TB; 84.2% participants are aware that TB is curable and; only 31% of the participants have heard of TB preventive treatment (TPT). This study has been able to examine the degree of awareness and perspectives of tuberculosis in terms of the basic knowledge of TB, TB screening, TB-associated stigma, TB diagnosis, TB curability and TPT among the working population in Lagos State, this is very crucial to control TB in the country.

Keywords: *Curability, Diagnosis, Prevention, Screening, Stigma, Tuberculosis.*

Introduction

Tuberculosis (TB) remains one of the most infectious diseases and one of the major causes of morbidity and deaths worldwide. TB is known to cause morbidity in over 10 million persons every year and an estimated 1.30 million deaths globally with an estimated 410 000 people developing multidrug-resistant or rifampicin resistant TB (MDR/RR-TB) [36]. Nigeria has one of the highest burdens for TB, TB/HIV co-infection and multidrug resistant TB. A notable development was documented for Nigeria in 2020, 138,591 cases notified, which is 15% higher than previous years [3, 35]. Nevertheless, more than 300,000 of the estimated 440,000 new TB cases are still missing annually. According to WHO's Global Tuberculosis Report, 2023, Nigeria has a 4.5% burden of TB globally and Lagos State accounts for 11% of this burden which was very alarming in 2022. Although, Nigeria has embraced the Directly Observed Therapy Short course (DOTS), a strategy to control TB control since 2004 and over 5,000 DOTs facilities have been adopted in treatment facilities across the country [13].

However, in 2016, the 'End TB Strategy' was adopted with the goal to reduce the incidence of TB by 85%, and mortality related to TB by 90% by the year 2030 [31; 35].

Tuberculosis is an airborne disease, and it is caused by a pathogen called *Mycobacterium tuberculosis* [11]. Tuberculosis infection

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occurs when the aerosol droplets carrying the bacilli of *M. tuberculosis* are inhaled, but not everyone infected becomes sick. *M. tuberculosis* infection can be asymptomatic initially and develops into latent tuberculosis (whereby the patient gets well clinically without symptoms but remains a carrier of the tuberculosis bacilli) [8]. Research has shown that only about 5–10% of patients with *M. tuberculosis* infection will most likely develop active TB (primary TB) immediately after the incubation period, and this is identified by clinical symptoms of TB disease (cough of more than 2 weeks, fever of more than 3 weeks, unexplained weight loss and drenching night sweat) [26]. Nevertheless, the reactivation of latent TB infection can occur anytime in a carrier's life (secondary TB), once the immune system can't trigger or sustain an effectual immune response.

The important factors responsible for the immediate replication of *M. tuberculosis* bacilli and advancement to active TB are bacterial load inhaled, age, malnutrition and immune deficiencies [11]. Other major risk factors of TB are socioeconomic factors (poverty, malnutrition, wars); immunosuppression: (HIV/AIDS, chronic immunosuppressive therapy such as steroids, monoclonal antibodies against tumor necrotic factor, a poorly developed immune system in children and primary immunodeficiency disorders) and occupational (mining, construction workers, pneumoconiosis) [4].

TB patients are highly discriminated and stigmatized by their families, communities and even health workers because TB is a contagious disease that can be transmitted by sharing of the same cutlery, its association with HIV infection; the idea that TB sufferers have done something immoral like smoking, and its association with poverty [19]. Stigma is a social behavior that occurs when specific traits of a person are learned to be undesirable or determined to be undeserving. Stigmatization has negative effect on TB patients such as reducing their self-esteem, delay in diagnosis and treatment, deliberate denial of diagnosis when done, defaulting in treatment and as a result multidrug resistance could develop, thereby increasing the transmission of TB within the society [12, 19, 21]. Also, stigma persists against people who are infected with TB because of the lack of understanding of TB prevention and control which includes prescribing TB Preventive Treatment (TPT) to non-presumptives contacts of the index TB case.

TB is curable and its regimens have changed over time. Currently, the standard of care for persons infected with drug-susceptible TB disease is a 6-month regimen of four first-line drugs: isoniazid, rifampicin, ethambutol and pyrazinamide [32]. The treatment of persons infected with drug-resistant TB requires regimens that include second-line drugs [33]. The prevention and the stop of the development of latent TB infection to active disease is very important to reduce TB incidence to the levels predicted by the End TB Strategy. And this can only be achieved by educating people living with HIV, household contacts of people with TB and other risk groups about TB prevention and control which includes prescribing TB Preventive Treatment (TPT) to non-presumptives contacts of the index TB case and immunizing children with the Bacille Calmette-Guérin (BCG) vaccine [34]. There have been a lot of new developments in epidemiological reports, new immunodiagnostic tests and molecular methods that allow rapid microbiological diagnosis and detection of variants of *M. tuberculosis* associated with drug resistance. Also, there are discovery of novel second-line antituberculosis drugs including for TB infected children, and the results of clinical trials have proven that there can be shorter duration of treatment for some TB patients [7].

TB continues to be an important public health concern in Lagos State, Nigeria, as it accounts for 11% of this burden in the country while Nigeria has a 4.5% burden of TB globally

[36]. The important factors responsible for the TB burden in Lagos include the accelerated population growth, high poverty level in the slums, HIV/AIDS epidemic and the increase in multidrug drug resistance TB [3, 30]. Lagos state is an urban center that has a lot of slums communities. The slum communities are usually exposed to TB due to the unhygienic living conditions, overcrowding tendency, high poverty levels and barriers (such as bad roads network) restricting access to health promotion, preventive and treatment services [6]. The workers who live in slums relate and interact with workers who live in a decent and conducive environment during their time at work which usually last for at least 8 hours of the day, for at least 5 working days in a week. Also, the working population are the most active population subset of the society (mostly bread winner of the family), and they work in various sectors of the labour market. As a result of this, they are the most exposed to TB and would likely infect their household with TB if they get infected at their workplace.

Hence, having basic knowledge of TB, TB screening, TB-associated stigma, TB diagnosis, TB curability and TB preventive treatment among the working population is very crucial to control TB. However, to the best of my knowledge no study has assessed the awareness and knowledge of TB among the working population across local government areas (LGAs) in Lagos State, Nigeria. This study sought to assess TB awareness and answer the question what the perspectives of TB among the working population across Lagos State are, hence, the central aim of this study was to assess tuberculosis awareness and perspectives among the working population across all local government areas in Lagos State within 5 months.

Materials and Methods

Study Design

A cross-sectional study design was employed. Socio-demographic data (age, gender, highest level of education, local government area, and employment status) from deidentified persons who gave consent were investigated using a structured and pretested questionnaire in a Google Form.

Study Area

This study took place in Lagos State, the largest urban city in Nigeria. Lagos State is located in South–Western part of Nigeria. Lagos State lies approximately on a longitude of 20 42'E and 32 2'E respectively, and between latitude 60 22'N and 60 2'N. Lagos State is surrounded in the north and east by Ogun State of Nigeria, and in the west by the Republic of Benin. It extends for 180 kilometers along the Guinea Coast of the Bight of Benin on the Atlantic Ocean. Lagos State population was 14,862,000 as of 2021 [18]. Lagos State has twenty local government areas namely Agege, Ajeromi-Ifelodun, Alimosho, Amuwo-Odofin, Apapa, Badagry, Epe, Eti-Osa, Ibeju-Lekki, Ifako-Ijaiye, Ikeja, Ikorodu, Kosofe, Lagos Island, Lagos Mainland, Mushin, Ojo, Oshodi-Isolo, Shomolu, Surulere.

Study Population

The questionnaires were only administered to employed persons who work in Lagos, Nigeria who gave consent.

Study Duration

This study lasted for five months.

Sampling Method

This study used the non-probability method using the convenience sampling type.

Sample Size

A minimum sample size of two hundred and seventy-five (275) was calculated from the formula described by Fisher formula for sample collection [14]. A sample size that is greater than the value of 275 was used to improve the precision estimates of this study. Fisher's formula: $n= Z^2p\ (1-p)/d^{2.}$ Where n is minimum sample size; Z is the critical value; p is the

prevalence of sample and d is precision. According to the study of Adejumo et al., 2018 [1], the prevalence of 23.4% (0.234) was used to calculate the sample size using the critical value of 1.96 (confidence interval of 95%) and a precision of 5% (0.05).

Study Tools

The structured questionnaire was the main tool that was used in this study, and it included the respondent consent section.

Pretesting

The survey questions and questionnaires were pretested among the working population in Lagos State; to assess how reliable and valid the questions are before the final link for the questionnaire were sent out to the working population in Lagos State.

Data Collection

Data were collected from the responses of the Google Form of the structured questionnaires that were administered to participants who gave consent. The data collected were used to assess the basic knowledge of TB, knowledge of TB screening, stigma, diagnosis, TB curability and TB preventive treatment.

Data Analysis

The data obtained were analyzed by using Microsoft Excel and Google Sheet Pivot and were presented in tables and charts.

Ethical Consideration

Ethical approval was obtained from the College of Medicine of University of Lagos Health Research Ethics Committee. All the data from the respondents of questionnaires who met the inclusion criteria were analyzed.

Results

A total of 350 participants completed the structured questionnaire but only 310 participants met the inclusion criteria of working and living in Lagos State (Figure 1, Table 1).

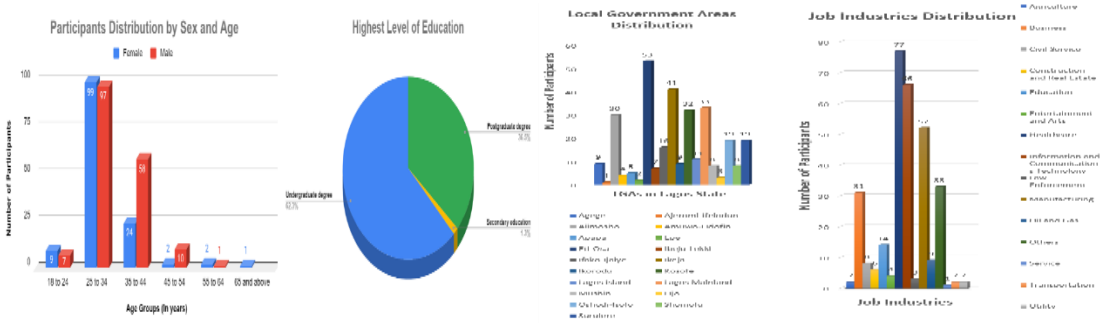

Figure 1. Demographic Features of the Respondents

Table 1. Knowledge of TB by Respondents' Job Industries in Lagos State

Industry	No	Yes	Grand Total
Agriculture	0	2	2
Business	2	29	31
Civil Service	1	7	8
Construction and Real Estate	0	6	6
Education	1	13	14
Entertainment and Arts	0	4	4
Healthcare	1	76	77
Information and Communications Technology	2	64	66

Law Enforcement	0	3	3
Manufacturing	2	50	52
Oil and Gas	0	9	9
Others	2	23	25
Self employed	0	8	8
Service	0	1	1
Transportation	0	2	2
Utility	0	2	2
Grand Total	11	299	310

In this study, 96.5% of the participants have heard of TB before; only 36.5% knew what TB is called in their local dialect; 75.8% know TB is caused by a microorganism; 83.2% know the signs and symptoms of TB; 91.6% of the participants know the contagiousness of TB; 91.9% admitted that importance of the knowledge of TB endemicity in Nigeria; 66 % learnt about TB in school (Table 2).

Table 2. Basic Knowledge of TB among the Working Population in Lagos State n=310

Knowledge	**Percentage Score for Answer**
Heard of TB before	
Yes	299 (96%)
No	11 (4%)
Knowledge of TB in local dialect	
Know	113 (36%)
Don't know	164 (53%)
Not applicable	33 (11%)
TB was first learnt from:	
Workplace	1 (0.3%)
School	205 (66%)
Pre-employment health screening	1 (0.3%)
Self-learnt	1 (0.3%)
Friends and family	47 (15%)
Health care providers	20 (7%)
Media	35 (11%)
Cause of TB	
Air	30 (10%)
Cold	7 (2%)
Microorganism	235 (76%)
Smoking	2 (0.6%)
Transmitted from one person to another	1 (0.3)
Not sure the cause	2 (0.6%)
Don't know	33 (11%)
Signs and Symptoms of TB	
Breathlessness	1 (0.3%)
Cough and loss of weight	1 (0.3%)

Cough, fever, night sweat, unexplained weight loss	258 (83.2%)
Coughing out blood only	36 (11.6%)
Losing weight drastically only	3 (1.0%)
Don't know	11 (3.6%)
Knowledge of the contagiousness of TB	
Yes	284 (91.6%)
No	9 (2.9%)
Don't know	17 (5.5%)
Importance of the knowledge of TB endemic in Nigeria	
Very important	285 (91.9%)
Somewhat important	21 (6.8%)
Not very important	2 (0.6%)
Don't know	2 (0.6%)

Also, only 45.2% of the participants have ever been screened for TB; 9.7% implied they have TB associated stigma behavior; 67.7% of participants knew at least one method of TB diagnosis (Figure 2).

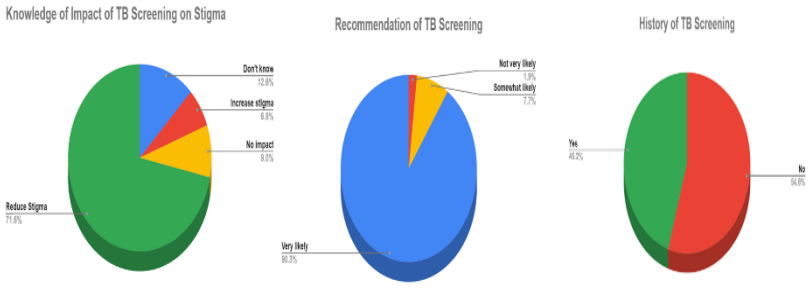

Figure 2. Knowledge of Tuberculosis Screening among the Working Population in Lagos State

Moreover, only 2.9% (9) among the participants have been diagnosed of TB, and only one person out of the nine diagnosed TB patients didn't complete anti-TB treatment; 84.2% participants are aware that TB is curable (Figure 3).

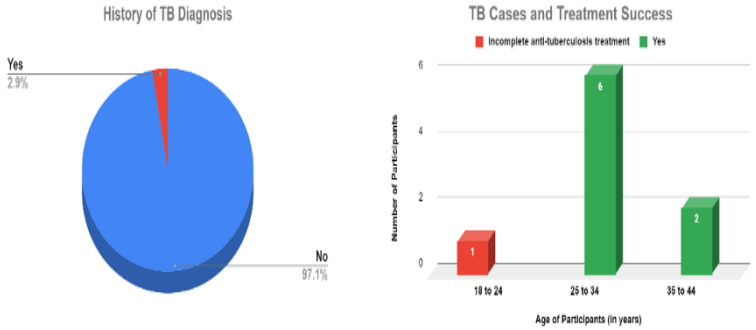

Figure 3. History of TB Diagnosis and Treatment Outcome among the Working Population in Lagos

However, only 31% of the participants have heard of TB preventive treatment and only 92% among them are actually aware of its benefits (Table 3).

Table 3. Knowledge of TPT among the Working Population in Lagos State n=310

Knowledge of TB Preventive Treatment	**Number of Participants**
Heard of TB Preventive Treatment before	
Yes	96 (31%)
Awareness of the benefits of TPT	92 (96%)
Unawareness of the benefits of TPT	4 (4%)
No	214 (69%)
Awareness of the benefits of TPT	31 (14%)
Unawareness of the benefits of TPT	183 (86%)

Discussion

A total of 350 participants completed the structured questionnaire but only 310 participants met the inclusion criteria of working and living in Lagos State (Table 1, Figure 1). The responses from the 310 participants were used to determine and assess the basic knowledge of TB, TB screening, TB-associated stigma, TB diagnosis, TB curability and TB preventive treatment among the working population in Lagos State. To the best of my knowledge this is the first study to assess tuberculosis awareness and perspectives among the working population across all local government areas in Lagos State and Nigeria as a whole. TB is a known disease among the working population in Lagos State, as most of the respondents have heard about the infection (96.5%) (Table 2). This finding is similar to studies from Libya and Ethiopia that had 96.5% and 94.9% awareness of TB respectively [27, 29]. Also, my finding is also similar with studies done in Ogoja in Cross River, rural area in Lagos in Nigeria, urban area in Lagos, Enugu who had TB awareness of 97% 97.5%, 99.2% and 93% respectively [16, 21, 22]. While a study in Edo state had 86.5% TB awareness which is lower than my findings [28].

In this study, only 36.5% knew what TB is called in their local dialect and this did not correspond to the 96.5 % of the participants who have heard about TB (Table 2). This may be due to the fact that English is widely spoken in Lagos and it is the official language in Nigeria and considering that Lagos is an urban center and the former capital of Nigeria [5]. Another factor, is there is loss of the indigenous local dialect in Nigeria [15], and this must have contributed to 52.9% of the participants who don't know what TB is called in their local dialect and likewise 10.6 % of the participants who gave responses that were not applicable. Also, a lot of Nigerians who live and work in the urban cities like Lagos have lost touch of their origin as well their local dialect, because of the embrace of the culture of the west [5]. However, from the findings in this study, it is fair to say the working class in Lagos state having good basic knowledge of TB (96.5 % of the participants have heard of TB before; 75.8% know TB is caused by a microorganism; 83.2% know the signs and symptoms of TB; 91.6% of the participants know the contagiousness of TB; 91.9% admitted that knowledge of TB endemic in Nigeria is very important) (Table 2).

The major source of knowledge of TB in this study was school (66.1 %) through formal education and this is different from a study in urban slums in Lagos by Adepoju et al., 2022 [3], where their major sources of knowledge of TB were health care workers and the radio. The finding in this study is not surprising because the study population are the working class and the least education among the participants in this study was secondary education and individuals who have access to education and social media will likely have better knowledge and better perspectives about TB (Figure 1).

Education is a very important social determinant of health because it provides valid information for healthy living. Also, being educated forecasts good knowledge and perspectives about diseases such as TB. The school setting incorporates subjects such health education that promotes health of the public. This was evident in this study as 96.5% of the participants that know about TB are all educated and this was consistent with the study of Adepoju et al., 2022 [3] as compared with participants with no formal education (Figure 1).

The findings of this study also revealed that only 45.2% of the participants have been screened (Figure 2), despite the endemicity of TB in Nigeria and Lagos contributing 11% [2] and this is higher compared to studies done in Ethiopia where only 19.4% of the study participants were ever screened for TB [17] and in Thailand where only 18.6% of participants stated that they had undergone a TB screening test [23]. Also, when considering where the participants first learnt about TB in this study, only approximately 7% first learnt about TB from health care providers and 0.3% during their pre-employment health screening (Table 2). However, despite the low screening coverage among the working population in Lagos, 90.3% of participants recommends that TB screening should be done (Figure 2) and this suggest that these participants are most likely to be more receptive to being screened for TB during their pre-employment health screening and their visit to the health care facilities if TB screening services are offered to them.

This present study reveals stigmatization is present among the working population in Lagos but is not high (9.7%) compared to a study in the year 2020 in the urban city of Lagos where 95.7% of the respondents were associated with TB stigma behavior [21], and a study in Thailand where 22.5% of community members would think less of TB patients [25]. Other studies in India (reported 73%), Tunisa (reported 54.9%) Pakistan (reported 47.9%) all had higher prevalence of TB-associated stigmatization [10, 20, 24] compared to this study. This study revea1s that 1.3% of the participants said they will start avoiding any person who is suspected to have TB or a confirmed TB case; 0.3% will reduce interaction with the presumptive (suspected) TB case or a confirmed TB case but ask them to seek medical care and 8.1% will stop sharing personal items with the presumptive TB case or a confirmed TB case. Noteworthy to mention, 89.7% of the participants said they will advise the presumptive TB case or a confirmed TB case to seek medical care and this is because they are well educated (62.3% of the participants have undergraduate education and 36.5% have postgraduate education) with least educated having a secondary school education (1.3% of the participants) and because they live an urban city like Lagos, they are most likely exposed to basic amenities, infrastructures and the media that disseminate information about public health issues (Figure 1). Also, majority of them have basic knowledge about TB (96.5%) and they are aware of the curability of TB (84.2%). The participants (26.7%) from information and communications technology industry implied they stigmatize TB presumptives and cases (Table 1), Surprisingly, 20% of the participants from the healthcare industry also suggested they will stigmatize TB presumptives and cases.

From this study, 67.7% of participants knew at least one method of TB diagnosis (Figure 2). Meanwhile, 32.3% did not have any knowledge about the method of TB diagnosis as compared to a study in Iran where 43% participants are not aware of what is the most important and accessible method for the diagnosis of pulmonary TB [9]. This could be because not all the participants are health care workers, only 24.8% of the participant work in the health care sector and only 3.9% among the participants from the healthcare sector are not aware of diagnosis of TB and these individuals will most likely be administrative staff of the healthcare

facility. The majority of the participants in this study are non-health workers (75.2%). Participants in the manufacturing had the highest percentage (17.1%) of participants who have knowledge of methods of TB diagnosis after the participants in the healthcare sector (34.8%) and 61.1% of them first learnt about TB in their schools, 11.1% from the healthcare providers, 13.9% each from their friends and media. Also, knowing fully well that screening (45.2%) is not optimal among the working population, this must have contributed to the lack of knowledge of types of TB diagnosis.

This study also reveals that only 2.9% among the participants has been diagnosed of TB, and only one person out of the nine diagnosed TB patients didn't complete anti-TB treatment (Figure 3). This might not be the reality of the working population in Lagos State because of the low screening coverage (45.2%) which is not optimal hence this must have contributed to the lack of knowledge of types of TB diagnosis and low TB cases identified, knowing that TB is endemic in Nigeria, [36].

Amazingly in this study, 84.2% participants are aware that TB is curable which is high as compared to a study by Adepoju et al., 2022 [3], in Lagos State where only about 48.4% of his study participants knew that TB is curable. Also, this study revealed 13.2% of the participants are not sure if TB is curable and 2.6% of them believes TB is not curable. Not surprisingly, the participants from the healthcare industry were the most aware of the curability of TB. Next to the health care sector was the information and communications technology industry who had 19.2% of their participants who are aware of TB curability and this as a result of their access to information on the internet. Noteworthy to mention, 8.4% of the participants who are aware of the curability of TB still implied that they will stigmatize people who are TB presumptives and TB cases, 14.3% of the participants who are not sure of the curability of TB also suggested they will stigmatize people who are TB presumptives and TB cases and 25% of the participants who believe that TB has no cure will stigmatize people who are TB presumptives and TB cases.

The awareness of TB preventive treatment is low, as only 31% of the participants of this study has heard of the TB preventive treatment and only 96% among them are aware of its benefits while 4% know nothing about its benefits (Table 3).

Conclusion

To the best of my knowledge, this is the first study on assessment of tuberculosis awareness and perspectives among the working population across Lagos State. This study has been able to provide the degree of awareness and perspectives of tuberculosis in terms of the basic knowledge of TB, TB screening, TB-associated stigma, TB diagnosis, TB curability and TB preventive treatment among the working population in Lagos State and this is very crucial to control TB in the country.

Conflict of Interest

There is no conflict of interest in this study.

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Application of Health Belief Model; Tuberculosis in Healthcare Workers: Risk Reduction Measures at Asokoro District Hospital (ADH) Abuja FCT Nigeria

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Abstract

Health Care workers (HCWs) in high tuberculosis (TB) burden settings are at increased risk of TB infection due to frequent exposure to TB patients and inconsistent implementation of TB risk reduction measures/TB Infection Prevention and Control (TB-IPC) practices. This study aimed to assess the risk of TB transmission and the practice of TB risk reduction measures among HCWs at Asokoro District Hospital (ADH), Abuja, FCT, Nigeria, utilizing the Health Belief Model (HBM). A quantitative study design was employed, using proportional stratified random sampling and purposive sampling, with data collected through Researcher-administered structured questionnaires via Open Data Kit (ODK) and a structured checklist. Results revealed high level of perceived susceptibility and severity among HCWs, with 87% acknowledging ADH as a high-TB burden health facility and 99% aware of TB's infectious nature. Nevertheless, barriers to practicing TB risk reduction measures were identified and the most notable one is the unavailability of N95 masks (reported by 99% of participants). Though, 94% of HCWs were willing to use alternative protection, albeit suboptimal, such as weak N95 masks. Perceived benefits of TB risk reduction measures practices were high, with 98% recognizing the importance of N95 masks and cross ventilation. Positive influence of cues to action, with 55% of participants receiving training on TB transmission and a strong association was found between training and adherence to TB risk reduction measures practices (B = 0.543, p = 0.000). The findings are mainly systemic inclined with few individualized ones: HCWs knowledge gap about TB mode of transmission, inadequate availability of protective equipment, limited training of HCWs on TB – IPC, lack of isolation unit and poor cross ventilation. Therefore, active interest and involvement of the hospital management in TB – IPC activities is critical to resolves all identified gaps.

Keywords: *Health Care Workers, Tuberculosis, TB Transmission, TB Risk Reduction Measures.*

Introduction

Tuberculosis (TB) is an infectious disease that affects mostly the lungs but other parts of the body could also be affected [1, 2]. It is caused by a type of bacteria known as Mycobacterium tuberculosis (Mtb) and it spreads through the air when infected person cough, sneeze or spit [1, 2]. Considerably, about a quarter of the global population is estimated to have been infected with TB bacteria and about 5–10% of people infected with TB will eventually develop TB disease [1, 3]. Some will be infected but may not become ill with the disease and those ones are described to be having Latent TB infection (LTBI) which is asymptomatic and cannot be transmitted [1, 4]. Worldwide, a total of 1.3 million people

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died from TB in 2022 (including 167, 000 people with HIV) and TB is the second leading infectious killer disease after COVID-19 (above HIV and AIDS) [1, 3]. TB remains a significant public health challenge globally, particularly in resource-limited settings [5].

Nigeria is ranked 6th among the 30 countries with highest TB burden globally and also has the highest TB burden in Africa [6, 7, 8]. Likewise, international TB data declared TB as a burdensome health problem in Nigeria [7, 8]. Additionally, on yearly basis, an estimate of 268,000 Nigerians die from TB, 590,000 new cases occur (of these, about 140,000 are also HIV-positive) [6, 7, 8]. Considerably, TB accounts for over 10% of all deaths and every hour nearly, 15 people die from the disease, despite the availability of TB treatment [6, 7, 8, 9]. Unfortunate, TB cases are under-reported especially in most developing countries in which Nigeria belong and this increased the high risk of transmission [6.8]. Significantly, it is estimated that one missed case can transmit TB to 15 people within a year [6.8]. Asokoro District Hospital (ADH) is one of the District Hospital in Abuja Federal Capital Territory in Nigeria – Africa. ADH has a Directly Observed Treatment Short-course Clinic where TB patients are referred to for diagnosis and treatment daily. In the past three years (2021 – 2023) as revealed by the hospital statistics, 361 individuals have been diagnosed and treated for TB [10]. Significantly, this high number of diagnosed TB patients made ADH to be rated as a TB high burden health care facility among others within the city [10]. Hence, this informed the Author of the need to assess the risk of TB transmission and TB risk reduction measures practice among all HCWs in the facility.

Significantly, World Health Organization (WHO) declared TB to be preventable if TB risk reduction measures/TB – Infection Prevention and Control (TB – IPC) is properly applied in any congregate setting [1, 11, 12]. TB risk reduction measures is a combination of actions planned to reduce the risk of TB transmission within populations [14.13]. Remarkably, most existing studies focused on policy compliance, infection prevention measures, and general TB control strategies [15]. However, there is a prominent gap in addressing the behavioral factors that influence HCWs' adherence to TB risk reduction measures in most health care settings [15]. By implication, Behavioral Health Theory Concepts (BHTC), such as the Health Belief Model, have been underutilized in this context. The HBM suggests that a person's health behavior is influenced by perceived susceptibility, severity, benefits, barriers, cues to action, and self-efficacy [16].

Literature Review

Tuberculosis and Health Care Workers (HCWs)

TB remains one of the most serious infectious diseases worldwide and HCWs are at an increased risk of the disease/infection due to job-related exposure [18,19]. Unfortunately, HCWs are three times more likely to contract TB compared to the general population especially in TB high-burden country like Nigeria [15]. Studies have consistently shown that with effective practice of TB risk reduction measures, the risk of TB transmission should be controlled effectively [18]. However, poor adherence to TB – IPC, continues to elevate HCWs' vulnerability to TB disease/infection [20]. Significantly, in health care facility such as ADH Abuja, TB risk of transmission has been a major concern to the Author due to the enormous numbers of positive TB cases seen daily: In the past three years (2021 – 2023) as revealed by the hospital statistics, 361 individuals have been diagnosed and treated for TB, insufficient infrastructure and inconsistent implementation of TB risk reduction measures [10]. Hence, this calls for further investigation. Remarkably, the risk of TB transmission in health care facilities not only affect HCWs but also have the potential to spread within the

broader community, affecting family members, other patients, and visitors [21].

The Health Belief Model (HBM) in Tuberculosis Control

The Health Belief Model (HBM) is one of the most widely used theoretical frameworks in public health to explain and predict health behaviors by focusing on the attitudes and beliefs of individuals [16, 22]. The HBM suggests that individuals' decisions regarding health behaviors are influenced by six key factors: perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy [16, 22]. In the context of TB transmission risk and the practice of TB risk reduction measures, the HBM has been employed to understand the likely factors that could be responsible in influencing the practice of TB risk reduction measures among the HCWs in a health care facility like ADH. Therefore, this study will demonstrate the critical need for behavioral interventions in TB risk reduction measures by addressing systemic barriers, enhancing HCWs' confidence and motivation that will aid or improve compliance. By implication, this study will fill critical gap in the literature. The results will contribute to the development of more effective, behaviorally informed TB risk reduction measures in health care settings like ADH. HBM six constructs that will be used in the assessment include:

1. **Perceived Susceptibility**: This refers to HCWs' having understanding that they are at an increased risk of been infected with TB in their workplace since it is a high TB burden area. Hence, this understanding is expected to influence strong adherence to the practice of TB risk reduction measures by any HCWs who work in such setting [16, 22].
2. **Perceived Severity**: Generally HCWs know the seriousness of having TB disease/infection with due consideration given to both medical and social consequences that accompany it. Therefore, it is expected that this knowledge should influence HCWs compliance to the practice of TB risk reduction measures in an environment with high TB risk of transmission [16, 22].
3. Perceived Benefits: The perception of beneficial protective measures against the risk of TB transmission among HCWs within the facility should serve as sources of motivation to engage in the practice of TB risk reduction measures. Examples of those perceived benefits of TB risk reduction measures are: knowing that ensuring cross ventilation, usage of N95 mask in TB highly risky area and performance of prompt triage in the out - patient clinic would reduce TB transmission should encourage HCWs to put these strategies into daily practice [16, 22].
4. **Perceived Barriers**: Identifying hindrances to performing recommended TB risk reduction measures such as lack of N95 mask, inadequate training of HCWs on TB – IPC, poor administrative support and many more can significantly inhibit HCWs' adherence to the practice of TB risk reduction measures [16, 22].
5. **Cues to Action**: Understanding of external triggers by HCWs that support the practice of TB – IPC Measures is equally important in achieving full practicing of TB risk reduction measures. External triggers like: positive institutional policies, having TB - IPC team in the facility and daily monitoring of all TB – IPC activities by the team members. Hence, once all these triggers are functioning effectively it is expected that they would serve as means of motivations and evaluation which should bring in sustainability and effective practice of TB risk reduction measures by the HCWs [16, 22].
6. **Self-Efficacy**: This refers to HCWs' having full confidence in their capacity to

successfully practice TB risk reduction measures effectively. Assurance of having sufficient and expected capacities by HCWs should serve as a strong encouraging factor of adherence to the recommended practice of TB risk reduction measures in a health care facility. Significantly, the assurance is built up via intentional HCWs capacity building activities: HCWs training on TB risk reduction measures, N95 fit training test and many more [16, 22].

Gaps in the Literature

Globally, numerous studies have utilized TB transmission risk and it prevention using the HBM among HCWs in several health care facilities. Regrettably, there is limited focus on its application to TB prevention among HCWs in Nigeria. In addition, while studies have examined the barriers to TB prevention in resource-limited settings, there is need for more research on how behavioral models, such as the HBM, can be tailored to specific health care institutions like ADH. Considerably, rigorous databased searches revealed that no similar study has been carried out among HCWs in ADH. Therefore, the Author of this study affirmed that this is a novel research which aimed at using HBM and it six constructs to assess the risk of TB transmission and the practice of TB risk reduction measures among HCWs in ADH. Hence, this study will bridged the critical gap that has been discovered in the literature. Ultimately, this study will ascertain the critical need for behavioral interventions in the practice of TB risk reduction measures. Also, the study will become useful in discovering how behavioral models, such as the HBM, can be tailored to specific health care institutions like ADH in the practice of TB risk reduction measures. Equally, it will contribute to the development of more effective, behaviorally informed TB preventive strategies in health care settings. Furthermore, it will determine systemic barriers and enhancing factors that could influence or motivate HCWs' confidence to embrace the practice of TB risk reduction measures. In addition, the study will motivate ADH management to provide maximum support to the practice of TB risk reduction measures within the health care facility. Likewise, the study will become relevant to the society and scientific world because the discoveries will be properly disseminated. In due course, HCWs in ADH Abuja will become extremely focused in ensuring full implementation of TB risk reduction measures. At global level, this move will contribute to the comprehensive End TB targets which aim at reducing TB mortality by 95% and incidence by 90 % in 2035 [17].

Problem Statement

Tragically, TB is very transmissible in resource-limited health care facilities [12, 22]. Therefore, most HCWs are at increased risk of acquiring TB in such settings if TB risk reduction measures are not fully adhered to [12, 23]. Asokoro District Hospital (ADH) is where this study was conducted and it is one of the district health care facilities in Abuja, within the Federal Capital Territory (FCT) of Nigeria in West Africa. In ADH, Numerous individuals are diagnosed and treated for TB on daily basis. Significantly, between 2021 and 2021, 361 individuals have been diagnosed and treated for TB in the health care facility [10]. As a result, it has been declared as a high TB burden area within the city of Abuja FCT in Nigeria – West Africa.

Similarly, it has become a high-risk health care facility to all HCWs and patients. This increased risk TB transmission within the health care facility is heightened by the daily high patient caseloads, insufficient infrastructure and often inconsistent implementation of TB risk reduction measures which has been observed by the Author. By implication, HCWs in ADH are particularly vulnerable to the risk of TB transmission which could be attributed to occupational exposure.

Equally, there is potential TB transmission risk extending beyond hospital environment to HCWs' families and the entire communities. Considerably, the risk of TB transmission in this setting is not only a threat to HCWs but also to other patients, especially immunocompromised individuals such as those living with Human Immunodeficiency Virus (HIV). Hence, this informed the choice of using HBM to understand the likely factors that could be responsible in influencing the practice of TB risk reduction measures among the HCWs within the health care facility.

Broad Objective: The aim of the study is to assess the risk of TB Transmission and the practice of TB risk reduction measures using Health Belief Model (HBM) among HCWs in ADH Abuja FCT Nigeria.

Research Objectives

1. To determine the socio-demographic characteristics of Health Care Workers in ADH Abuja Nigeria
2. To appraise the level of perceived threats (susceptibility and severity) of TB transmission risk among HCWs in ADH
3. To identify perceived barriers against the practice of TB risk reduction measures among HCWs in ADH
4. To discover the level of perceived benefits of TB risk reduction measures among HCWs in ADH
5. To assess the relationship between cues to action and self – efficacy of HCWs in ADH with the practice of TB risk reduction measures

Research Questions

1. What are the socio-demographic characteristics of Health Care Workers in ADH Abuja Nigeria?
2. What is the level of perceived threats (susceptibility and severity) of TB transmission risk among HCWs in ADH?
3. What are the perceived barriers against the practice of TB risk reduction measures among HCWs in ADH?
4. What is the level of perceived benefits of TB risk reduction measures among HCWs in ADH?
5. Is there a relationship between cues to action and self – efficacy of HCWs in ADH with the practice of TB risk reduction measures?

Significance of the Study

In health sector, research plays essential role in discovering new facts that are relevant to generate evidence based interventions which become useful to tackle several health challenges. Moreover, TB is a global public health issue that requires up-to-date evidence based facts generated through research to tackle it. Therefore, this study's findings will become relevant to several health care facilities in FCT Abuja, within the country where the study is conducted and even at international level. The Author will ensure appropriate dissemination of the study's finding to yield positive outcomes such as: active involvement of all ADH management members in TB – IPC activities within the health care facility, increase awareness and encourage full implementation of appropriate TB risk reduction measures among HCWs in ADH, renew commitment of TB- IPC stakeholders in ADH to prioritize screening of all HCWs prior to starting job and ensure periodic one for those working in TB high risk areas, discover all the barriers (individualized and systemic) against full implementation of TB risk reduction measures and provide means to gradually tackled each one, reduce the risk of developing TB disease/infection among HCWs in ADH, patients, family members, or visitors and particularly to PLHIV, attract the support and involvement of some non – governmental bodies that are interested in TP - IPC activities, generate several findings that will become very useful to formulate or improve already existing

health policies, strategies and interventions regarding TB – IPC in ADH and beyond and ultimately, contribute to the national and international goal of eradicating TB within the country and globally by 2030 and 2035 respectively.

Hypothesis

Null hypothesis (HO): There is no relationship between cues to action and self – efficacy of ADH HCWs with the practice of TB risk reduction measures

Alternate Hypothesis (HA): There is relationship between cues to action and self – efficacy of ADH HCWs with the practice of TB risk reduction measures

Materials and Methods

Study Design

Quantitative cross-sectional descriptive design was used in conjunction with Health Belief Model (HMB) Model Six Constructs to determine the level of perceived threats (susceptibility and severity), perceived barriers, perceived benefits, self - efficacy and cues to actions regarding the risk of TB transmission and the practice of TB risk preventive measures (TB - Infection Prevention and Control) among Health Care Workers (HCWs) in Asokoro District Hospital (ADH).

Furthermore, participant observational study was use to observe the practice of TB risk reduction measures among HCWs in selected out patients units within ADH. This is a research method that creates room for researcher to be involved in a particular setting or group with the sole aim of gathering information through observation of their practices [24]. The researcher has option to adopt the weakest (non-participatory) or strongest (most intensive) level of participation [24]. In this study, the weakest level of participatory (non-participatory) was used in order to reduce bias and at the same time an in-depth understanding into the practice of TB risk reduction measures was observed from insiders' perspective. Furthermore, Participant observation Study is a valuable method in a situation where unique practices and self - report of a practice may not generate desired information [24]. All these benefits mentioned above informed the Authors' decision to use the method because it created opportunity for a more detailed natural observation of TB risk reduction measure practices within the health care facility. Ultimately, this increase the validity of the study's' findings.

Study Site

Asokoro District Hospital (ADH) is the study area with bed capacity of 143 and the Hospital has since been providing comprehensive health care services in both clinical, training and research to FCT population and her environs (Health and Human Services Secretariat [25]. ADH is located at 31, Julius Nyerere crescent in Asokoro District of Abuja Federal Capital Territory (FCT). It is one of the 14 hospitals managed by the Hospitals Management Board (HMB) of the HHSS of the Federal Capital Territory Administration [25]. The Hospital was commissioned on the 3rd of December 2001 by the then President of the Federal Republic of Nigeria, Chief Olusegun Obasanjo [25]. ADH has a bed capacity of 143 and has been providing comprehensive health care services in clinical areas, training and research to FCT population and her environs [25]. Administratively the principal officers include: the Medical Director (MD), head of Clinical Services, the Hospital Secretary and heads of units: administrative and technical heads in units [25]. ADH has twenty four units and thirteen out patients departments [25].

Description of the Thirteen Outpatient Units

The participant observation study utilised Thirteen outpatient units (13) where diverse patients converge daily before being allocated to see Doctor and these include: Accident and Emergency, General Outpatient Department,

Medical Outpatient Department, Surgical Outpatient Department, Paediatric Outpatient Department, Ante Natal Clinic, Immunisation clinic, DOTS Clinic (Public Health), Social Work waiting bay, Physiotherapy waiting bay, Radiology waiting bay, Pharmacy waiting bay and Nutrition waiting bay. Moreover, a focal person from each unit was available during the observation for clarification concerning some situation and issues.

Population and Sample

The study population included all the HCWs in Asokoro District Hospital Abuja.

Sampling area 1: all HCWs in ADH who have one-on-one contact with patient on daily basis and have worked for minimum of 6 months in the health care facility were included.

Sampling area 2: all outpatient clinics were observed using participant observation.

Inclusion Criteria

1. All Healthcare workers who have had one –on-one contact with patient mostly on daily basis
2. All those that have worked for 6 months and above in the Health Care Facility
3. All HCWs that give consent
4. A representative of each outpatient unit that give consent
5. All outpatient clinic where more than one patients congregate daily

Exclusion Criteria

1. All healthcare workers that have no one-on-one contacts with patient
2. All those who has not worked up to 6 months in the Health Care Facility
3. All HCWs that do not to give consent
4. A representative of each outpatient unit that do not give consent
5. All outpatients clinic where only one patient stay on daily

Sample Size Determination

The populations' characteristics are diverse, therefore proportional stratified random sampling was used to ensure good representation of every characteristics [26]. At the end, the sample size of each stratum is proportionate to the population size of the stratum [26]. This sample side determination process prevents research bias (under coverage bias). Likewise, generalization and validity of the study is definite [26].

Stratified Sampling Formula = Total Sample Size / Entire Population * Population of Subgroups [27].

Sampling Technique for questionnaire (Stage 1)

A stratified multistage sampling technique (probability sample) was used to select the participant's for the quantitative design through the use of researcher – administered questionnaire (Table 1).

Table 1. List of All Units of HCWs in ADH

S/N	Units	Population Size	Meet Inclusion Criteria
1	Medical Doctors	110	Yes
2	Radiology	4	Yes
3	Physiotherapy	3	Yes
4	Optometry	5	Yes
5	Nursing	157	Yes
6	Pharmacy	32	Yes

7	Medical Laboratory	36	Yes
8	Health records	14	Yes
9	Hospital Health Assistant	47	Yes
10	Nutrition	4	Yes
11	Maintenance	9	No
12	Scientific Officers	2	No
13	Finance & Accounts	20	No
14	Auditors	2	No
15	Administrative	18	No
16	ICT	7	No
17	Prosthesis orthosis	1	Yes
18	Orthopedic plaster Technician	1	Yes
19	Institute of Human Virology of Nigeria (IHVN)	13	Yes
20	DOTS Clinic	5	Yes
21	Immunization & Family Planning	10	Yes
22	Social Work	3	Yes
23	NHIS	9	Yes
24	SERVICOM	2	No
	TOTAL	514	

Stage 2

The selection of HCWs that were used for the study was made using stratified sampling. The basis of the choice of sampling was informed by the already stated inclusion and exclusion criteria.

Stratified Sampling Formula: **Total Sample Size / Entire Population * Population of Subgroups** [27]:

Total sample size: This entails all the HCWs population in ADH= 454

Entire Population: This entails the target population based on the study inclusion and exclusion criteria =514

Population of subgroups: This entails the population of different group of participants in all the selected work units for the study e.g. Doctors are: 110; Nurses are: 157; Pharmacists are: 32 etc.

Example 454/514*110 (Doctors) = 97.1595 which is: 97 approximately (Number of Doctors to be used for the study Table 2.

Table 2. List of all Units of HCWs in ADH (Stratified Sample)

S/N	Units (strata)	Population size	Stratified sample size
1	Medical Doctors	110	97
2	Medical Laboratory	36	33
3	NHIS	9	8
4	Nursing	157	142
5	Radiology	4	4
6	Physiotherapy	3	3
7	Optometry	5	5
8	Pharmacy	32	29
9	Health records	14	13
10	Hospital Health Assistant	47	43
11	Nutrition	4	4
12	Prosthesis orthosis	1	1
13	Orthopedic plaster Technician	1	1
14	Institute of Human Virology of Nigeria (IHVN)	13	12
15	DOTS Clinic	5	4
16	Immunization & Family Planning	10	9
17	Social work	3	3
	TOTAL	454	412

Sampling Technique for observation method

Purposive sampling was used for the participant observational study which is the second part of quantitative study. Purposive sampling is one of the non – probability sample techniques where the target population is selected because such population will provide accurate information needed to achieve the study's objectives [28]. This sampling technique is commonly used in mixed methods research where rich information is required. Hence, to ensure rich and accurate information required for this study, the choice of purposive sampling was made by the Author based on the study's inclusion and exclusion criteria. Hence, thirteen (13) selected out patients units were used for the participant observational study. Below is the list of all the outpatient units that were observed using structured checklist during participant observational study.

1. Accident and Emergency
2. General Out Patient
3. Medical Out Patient
4. Surgical Out Patient
5. Pediatric Out patient
6. Ante Natal Clinic
7. Immunization clinic
8. DOTS Clinic (Public Health)
9. Radiology waiting bay
10. Pharmacy waiting bay
11. Social Work waiting bay
12. Physiotherapy waiting bay
13. Nutritionist waiting bay

Instruments for Data collection

researcher-administered structured questionnaire via open data kit (odk) and structured checklist (participant observation study) were used for the data collection

validity and reliability of Instruments

To ensure the content validity, the questionnaire and the structured checklist, their contents were reviewed with prior validated questionnaires and structured checklist of several similar validated studies. Likewise, the two data collection instruments were thoroughly reviewed by Six (6) senior public health experts including my well experienced supervisor using Lawshe's model [29]. Subsequently, a number of modifications were done based on expert's suggestions and modifications to endorse their suitability for this particular study. Furthermore, a pilot study was conducted on twenty – five (25) respondents out of 416 respondents. Consequently, all the respondents that participated in the pilot study were excluded from the main study. To guarantee an effective and efficient data collection process, three (3) research assistants were recruited and trained for two days on the objectives, methodology of the study and how to administer the questionnaire and the structured checklist appropriately. Anonymity were strictly adhered to during all the data collection processes which ultimately reassured the respondents that their status will be unidentified. Subsequently, this resulted into the respondents becoming very free while responding genuinely to all the questions.

Data Collection

The three trained research assistants collected the data using Open Data Kit (ODK) for over a period of three months (April to June 2023). Researcher - administered questionnaire was used to the stratified HCWs from different professions. The questionnaire sought to measure Socio – demographic and other general/work characteristics: gender, age, religion, marital status, educational level, job location, current profession and duration of employment.

Other measures that were taken include: HCWs perceived threats (susceptibility and perceived severity), perceived barriers, perceived benefits, self - efficacy and cues to actions regarding risk of TB transmission and the practice of TB risk reduction measures.

Similarly, structured checklist was used on the spot to assess the implementation and

practice of TB risk reduction measures in the thirteen (13) outpatients units.

Data Analysis

Data editing and validation was done on daily basis as soon as the already-filled questionnaires and structured checklists were submitted via ODK. All issues /problems detected were corrected instantly. Two separate files were created in the computer system to ensure double entries of data for safety and backup. The analysis of the questionnaire data was conducted using descriptive statistics, regression analysis, and correlation analysis. Descriptive statistics were employed to summarize the data and provide frequency distributions and percentage responses from healthcare workers (HCWs) regarding TB transmission risks, perceived barriers, and perceived benefits of TB risk reduction measures. The means and standard deviations were calculated to show the central tendencies and variations in participants' responses.

Regression analysis was conducted using SPSS version 24 to model the relationship between the dependent variable (practice of TB risk reduction measures) and independent variables (perceived threats, benefits, and barriers). The R^2 value was used to determine the proportion of variance in TB risk reduction practices explained by the predictors, and the significance of these predictors was evaluated using beta coefficients (β) and p-values.

Correlation analysis was performed to assess the relationships between perceived threats, barriers, and benefits. Pearson correlation coefficients were calculated to quantify the strength and direction of these relationships, with significance levels (p-values) indicating the reliability of the associations. The structured checklists was analyzed descriptively.

Ethical Issue

Ethical approval was obtained from the Medical Ethic Committee Asokoro District Hospital Abuja FCT Nigeria. Likewise, informed consent was obtained from each participant and the head of each outpatient unit before the commencement of data collection.

Results

The aim of the study is to assess the risk of TB Transmission and the practice of TB risk reduction measures using Health Belief Model (HBM) among HCWs in ADH Abuja FCT Nigeria. This is a quantitative study; researcher – administered questionnaire and structured checklist were used for data collection. HBM and it six constructs were utilised in this study to determine the risk of TB Transmission and the practice of TB risk reduction measures among HCWs in ADH Abuja FCT Nigeria.

Quantitative study results using researcher- administered questionnaire

Socio – demographic characteristics of study population

A total of 391 HCWs participated in the study which give a response rate of 100% (55% females and 45% males) as participants. 17.4% were below age 30, 34.8% were between 31 and 40 years, 32.5% were between 41 – 50 years and 15.3% were between 51 and 60 years. Majority of the participants are Christians (83.9%) with 70.8% married among them. Above half (62.7%) of the study participants have 1st degree, while 16.9% have 2nd degree and above, 9.0% are with diploma and 11.5% possess secondary school education and below. Majority of participants (42.2%) work in diverse units which is classified as others and 21.7% work in the wards, 11.3% work at Out Patients Department, 8.4% work in Laboratory, 7.7% work in Pharmacy and participants who work in Health Records are just 3.3%. In terms of profession, 33% of the participants are Nurses, Doctors are 21.7%, Laboratory Scientists are 8.4%, Pharmacists are 7.9%, Health Record Officers are 5.4% others are 19.2%. Bulk of participants (43.7%) fall within 4 – 9 years duration of employment, 33% of

participants have spent 10 years and above and 23.3% participants are within 1 – 4 years duration of employment. Table 3.

Table 3. Frequency Distribution of the Socio-Demographic Characteristics of Study Population (N=391)

Variables	Categories	Frequency	Percentage
Gender	Female	215	55%
	Male	176	45%
Age (years)	< 30 years	68	17.4%
	31 - 40 years	136	34.8%
	41 - 50 years	127	32.5%
	51 - 60 years	60	15.3%
Religion	Christianity	328	83.9%
	Islam	62	15.9%
	Others	1	0.3%
Marital status	Married	277	70.8%
	Single	107	27.4%
	Widowed	5	1.3%
	Divorced	1	0.3%
	Others	1	0.3%
Educational level	1st degree	245	62.7%
	2nd degree and above	66	16.9%
	Secondary level and below	45	11.5%
	Diploma	35	9.0%
Job location	Others	165	42.2%
	Ward	85	21.7%
	OPD	44	11.3%
	Laboratory	33	8.4%
	Pharmacy	30	7.7%
	Health record	13	3.3%
	NHIS	9	2.3%
	Radiology	4	1.0%
	DOTS clinic	4	1.0%
	Physiotherapy	4	1.0%
Participant's profession	Nurse	129	33%
	Doctor	85	21.7%
	Others	75	19.2%
	Laboratory Scientist	33	8.4%
	Pharmacist	31	7.9%
	Health Record Officer	21	5.4%
	Community Extension workers	5	1.3%
	Nutritionist/Dietitian	4	1.0%
	Radiologist	4	1.0%

	Physiotherapist	3	0.8%
	Health Record Officer	1	0.3%
Duration of employment (years)	4 – 9 years	171	43.7%
	10 years and above	129	33.0%
	1 - 4 years	91	23.3%

To Appraise the Level of Perceived Threats (susceptibility and severity) of TB Transmission Risk among HCWs in ADH

Frequency Distribution

Majority of participants (87%) are aware that ADH is a TB high burden Health Care Facility whereas just few (13%) showed lack of awareness of that fact. Almost all participants (99%) know that TB is highly infectious, similarly, most participants agreed to the fact that an individual with TB infection can develop TB disease several years later. A greater percentage (83%, 82% & 95%) of the participants also know that TB can spread from infected patient through: laughing, singing and talking. Furthermore, most participants (are also aware that TB bacteria can survive in the air for more than 6 hours, TB bacteria can survive for 6 months on surfaces and in humid, dusty and dark environments. 75% participants equally know that having had BCG is not an absolute guaranty that one cannot develop TB later in life. Table 4

Table 4. Frequency Distribution for Level of Perceived Threats (susceptibility and severity) of TB Transmission Risk among HCWs in ADH

Variables	True (%)	False (%)
Knowledge that ADH is a TB high burden area	339 (86.7%)	52 (13.3%)
TB is often spread from person to person through sex	161 (41.2%)	230 (58.8%)
TB is often spread from person to person through the air	389 (99.5%)	2 (0.5%)
TB is often spread from person to person through blood	346 (88.5%)	45 (11.5%)
Only people with active TB disease in the lungs or throat are infectious	346 (88.5%)	45 (11.5%)
People can be infected with TB and have TB infection	387 (99.0%)	4 (1.0%)
People with TB infection can develop TB disease some years later	380 (97.2%)	11 (2.8%)

Patients with active TB disease can infect people by laughing	323 (82.6%)	68 (17.4%)
Patient with active TB disease can infect people by singing	319 (81.6%)	72 (18.4%)
Patients with active TB disease can infect people by sharing same plate	206 (52.7%)	185 (47.3%)
Patients with active TB disease can infect people by sharing bed linens	278 (71.1%)	113 (28.9%)
Patients with active TB disease can infect people by talking	372 (95.1%)	19 (4.9%)
TB bacteria can survive for up to 6 hours in the air	343 (87.7%)	48 (12.3%)
TB bacteria can survive on surfaces for up to 6 months if it is protected from direct sunlight	319 (81.6%)	72 (18.4%)
TB Bacteria can survive in dusty, humid and dark environment for up to 6 months	261 (66.8%)	130 (33.2%)
Baccile Calmette – Guerin (BCG) Vaccination does not completely protect people from having TB	294 (75.2%)	97 (24.8%)
Usage of Household Bleach (Sodium Hypochlorite) as disinfectant to clean surfaces destroys TB bacteria	366 (93.6%)	25(6.4%)

Descriptive Statistics

The descriptive statistics findings indicated that most participants are aware of key aspects of TB transmission risks. The mean score for awareness that ADH is a TB high burden area is 1.1330 (SD = 0.34000), which is an indication of high level TB transmission perception. Participants strongly agreed that TB spreads through the air (mean = 1.0051, SD = 0.07143), while there is less agreement about TB spreading through sexual contact (mean = 1.5882, SD = 0.49278) or blood (mean = 1.8389, SD = 0.36812). Participants also recognized that TB can be transmitted by actions such as laughing (mean = 1.1739, SD = 0.37952), singing (mean = 1.1841, SD = 0.38810), and talking (mean = 1.0486, SD = 0.21529). Also, participants showed strong knowledge of the survival of TB bacteria in the air for up to six hours (mean = 1.1228, SD = 0.32858) and on surfaces for six months (mean = 1.1841, SD = 0.38810). There is broad understanding that BCG vaccination does not fully protect against TB (mean = 1.2481, SD = 0.43245), and that bleach can effectively

destroy TB bacteria (mean = 1.0639, SD = 0.24496). Table 5

In summary the study revealed high level of perceived threats (susceptibility and severity) of TB transmission risk among HCWs in ADH with the mean score of 1.1330 (SD = 0.34000)

Table 5. Descriptive Statistics for Level of Perceived Threats (susceptibility and severity) of TB Transmission Risk among HCWs in ADH

Variables	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Do you know that ADH is a TB high burden area?	391	1.00	2.00	1.1330	.34000
TB is often spread from person to person through sex?	391	1.00	2.00	1.5882	.49278
TB is often spread from person to person through the air	391	1.00	2.00	1.0051	.07143
TB is often spread from person to person through blood	391	1.00	2.00	1.8389	.36812
Only people with active TB disease in the lungs or throat are infectious	391	1.00	2.00	1.1151	.31954
People can be infected with TB and have TB infection	391	1.00	2.00	1.0102	.10075
People with TB infection can develop TB disease some years later	391	1.00	2.00	1.0281	.16556
Patients with active TB disease can infect people by laughing	391	1.00	2.00	1.1739	.37952
Patient with active TB disease can infect people by singing	391	1.00	2.00	1.1841	.38810
Patients with active TB disease can infect people by sharing same plate	391	1.00	2.00	1.4731	.49992
Patients with active TB disease can infect people by sharing bed linens	391	1.00	2.00	1.2890	.45388
Patients with active TB disease can infect people by talking	391	1.00	2.00	1.0486	.21529
TB bacteria can survive for up to 6 hours in the air	391	1.00	2.00	1.1228	.32858

TB bacteria can survive on surfaces for up to 6 months if it is protected from direct sunlight	391	1.00	2.00	1.1841	.38810
TB Bacteria can survive in dusty, humid and dark environment for up to 6 months	391	1.00	2.00	1.3325	.47171
Baccile Calmette – Guerin (BCG) Vaccination does not completely protect people from having TB	391	1.00	2.00	1.2481	.43245
Usage of Household Bleach (Sodium Hypochlorite) as disinfectant to clean surfaces destroys TB bacteria	391	1.00	2.00	1.0639	.24496
Valid N (listwise)	391				

To Identify Perceived Barriers Against the Practice of TB Risk Reduction Measures among HCWs in ADH

Frequency Distribution

83% of participants believed that the usage of surgical masks by HCWs could prevent TB bacteria from being breath in. 94% participants agreed that a weak N95 mask/FFP2 can be used if there is no new one available. Significantly, majority of participants (99%) agreed that unavailability of N95 masks for usage by the HCWs is a major barrier towards the practice of TB risk1 reduction measures. Table 6.

Table 6. Frequency Distribution for Perceived Barriers against the Practice of TB Risk Reduction Measures among HCWs in ADH

Variables	**Yes (%)**	**No (%)**
Usage of surgical masks by HCWs prevent TB bacteria from being breathed in	325 (83.1%)	66 (16.9%)
A weak N95 mask/FFP2 can still be used in the absence of none	270 (93.6%)	121 (30.9%)
Lack of N95 masks for healthcare workers in high-risk areas exposes them to higher risk of developing TB infection/disease	386 (98.7%)	5(1.3%)

Descriptive statistics

The descriptive statistics results indicated that most participants agree that using surgical masks by healthcare workers can help prevent the inhalation of TB bacteria, with a mean score of 1.1688 and a standard deviation of 0.37505. Regarding the use of weak N95 masks or FFP2 in the absence of better alternatives, participants displayed moderate agreement, with a mean score of 1.3095 and a standard deviation of 0.46286. There is a strong consensus among participants that a lack of N95 masks for healthcare workers in high-risk areas exposes them to a higher risk of developing TB infection or disease, as indicated by a mean score of 1.0128 and a low standard deviation of 0.11250. Table 7.

The findings discovered that insufficient supply of N95 masks could increase risk of TB transmission (mean score of 1.0128 and a low standard deviation of 0.11250). Also, demonstration of extremely low understanding of the content of TB risk reduction measures was displayed by having most participants believing that surgical mask or weak N95 mask can prevent TB transmission with mean score of 1.1688 and SD of 0.37505 and mean score of 1.3095 and SD of 0.46286 respectively.

Table 7. Descriptive Statistics for Perceived Barriers against the Practice of TB risk Reduction Measures among HCWs in ADH

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Usage of surgical masks by HCWs prevent TB bacteria from being breathed in	391	1.00	2.00	1.1688	.37505
A weak N95 mask/FFP2 can still be used in the absence of none	391	1.00	2.00	1.3095	.46286
Lack of N95 masks for healthcare workers in high-risk areas exposes them to higher risk of developing TB infection/disease	391	1.00	2.00	1.0128	.11250
Valid N (listwise)	391				

To discover the level of perceived benefits of TB risk reduction measures among HCWs in ADH

Frequency Distribution

98% participants stated that the usage of N95 mask is a great TB risk reduction measures among HCWs and 89% agreed that the usage of surgical masks by TB patients will greatly help to prevent the spread of TB. Most participants (98%) also stated that keeping windows and doors open will surely prevent the spread of TB within the Health Care Facility. Table 8.

Table 8. Frequency Distribution for Level of Perceived Benefits of TB Risk Reduction Measures among HCWs in ADH

Variables	Yes (%)	No (%)
Usage of N95 masks/ Filtering Face Piece (FFP2) by HCWs prevent TB bacteria from being breathed in	384 (98.2%)	7 (1.8%)

Usage of surgical mask by TB patient prevent from expelling TB bacteria into the air	349 (89.3%)	42 (10.7%)
Keeping doors and windows open helps to reduce the spread of TB bacteria	384 (98.2%)	7 (1.8%)

Descriptive statistics

The findings showed that almost all participants agreed that using N95 masks or Filtering Face Pieces (FFP2) by healthcare workers can prevent TB bacteria from being inhaled, with a mean score of 1.0179 and a standard deviation of 0.13277. Similarly, most participants approved that the usage of surgical masks by TB patients helps prevent the expulsion of TB bacteria into the air, with a mean score of 1.1074 and a standard deviation of 0.31004. There is also strong consensus that keeping doors and windows open reduces the spread of TB bacteria, as reflected by a mean score of 1.0179 and a standard deviation of 0.13277. Table 9

The study emphasised high level of perceived benefits of TB risk reduction measures and practices among ADH HCWs were revealed. Usage of N95 masks by HCWs: mean score of 1.0179 and SD 0.13277, usage of surgical masks by TB patients: mean score of 1.1074 and SD of 0.31004 and strong consensus of keeping doors and windows open: mean score of 1.0179 and SD of 0.13277.

Table 9. Descriptive Statistics for Level of Perceived Benefits of TB Risk Reduction Measures among HCWs in ADH

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Usage of N95 masks/ Filtering Face Piece (FFP2) by HCWs prevent TB bacteria from being breathed in	391	1.00	2.00	1.0179	.13277
Usage of surgical mask by TB patient prevent from expelling TB bacteria into the air	391	1.00	2.00	1.1074	.31004
Keeping doors and windows open helps to reduce the spread of TB bacteria	391	1.00	2.00	1.0179	.13277
Valid N (listwise)	391				

To Assess the Relationship between Cues to Action and Self – Efficacy of HCWs with TB Risk Reduction Measures Practices

Frequency Distribution

All participants (100%) agreed with the statement that the spread of TB should be prevented in any Health Care Facility and there should be official TB infection control policy. Nevertheless, only 55% and 47% participants have received training on TB transmission and TB transmission risk reduction measures respectively. Table 10

Table 10. Frequency Distribution for Relationship between Cues to Action and Self – Efficacy of HCWs in ADH with the Practice of tb Risk Reduction Measures

Variables	Yes (%)	No (%)
It is very important to prevent the spread of TB in any Healthcare Facility	390 (99.7%)	1 (0.3%)
It is important for every Healthcare Facility to have an official TB infection control policy	391 (100%)	0 (0%)
Have you received training on TB Transmission	214 (54.7%)	117 (45.3%)
Have you received training on TB Transmission Risk Reduction Measures (TB Infection Prevention and Control) i.e IPC on TB	185 (47.3%)	206 (52.7%)

Descriptive Statistics

According to the result, the importance of preventing the spread of TB in healthcare facilities is universally acknowledged, with all participants (mean = 1.0000, SD = 0.00000) agreeing that it is very important to prevent the spread of TB in any healthcare facility. Additionally, almost all participants (mean = 1.0026, SD = 0.05057) believe it is important for every healthcare facility to have an official TB infection control policy. Regarding training, a significant portion of participants (mean = 1.4527, SD = 0.49839) have received training on TB transmission, though not all. Similarly, slightly more participants (mean = 1.5269, SD = 0.49992) have received training specifically on TB transmission risk reduction measures or infection prevention and control (IPC) related to TB. Table 11

Table 11. Descriptive Statistics for Relationship between Cues to Action and Self – Efficacy of HCWs in ADH with the Practice of TB Risk Reduction Measures

Variables	N	Minimum	Maximum	Mean	Std. Deviation
It is very important to prevent the spread of TB in any Healthcare Facility	391	1.00	1.00	1.0000	.00000
It is important for every Healthcare Facility to have an official TB infection control policy	391	1.00	2.00	1.0026	.05057
Have you received training on TB Transmission	391	1.00	2.00	1.4527	.49839

Have you received training on TB Transmission Risk Reduction Measures (TB Infection Prevention and Control) i.e IPC on TB	391	1.00	2.00	1.5269	.49992
Valid N (listwise)	391				

Regression Analysis to assess relationship between cues to action and self – efficacy of HCWs in ADH with the practice of TB risk reduction measures

The regression analysis shows that the model, including the variables related to training on TB transmission, TB infection prevention and control (IPC), and the presence of an official TB infection control policy, explains 19.2% of the variance in TB risk reduction ($R^2 = 0.192$). The F-statistic is 30.242, with a p-value of 0.000, indicating that the model is statistically significant. In terms of the coefficient of variance, the results show that training on TB transmission has a positive impact on TB risk reduction (B = 0.193, p = 0.004). Receiving training on TB transmission risk reduction measures, such as IPC on TB, has a strong positive effect on TB risk reduction (B = 0.543, p = 0.000), signifying that this type of training is highly effective. On the other hand, having an official TB infection control policy in healthcare facilities was not a statistically significant predictor (B = 0.346, p = 0.416), suggesting that simply having a policy without adequate training may not be enough to drive significant risk reduction. The results suggest that receiving training on TB transmission and TB risk reduction measures, as well as having an official TB infection control policy in healthcare facilities, significantly contribute to reducing TB transmission risk among HCWs. Tables 12, 13, 14

Table 12. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.439[a]	.192	.186	.41939

a. Predictors: (Constant), Have you received training on TB Transmission Risk Reduction Measures (TB Infection Prevention and Control) i.e IPC on TB, It is important for every Healthcare facility to have an official TB infection control policy, Have you received training on TB Transmission

Table 13. Analysis of Variance

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	15.958	3	5.319	30.242	.000[b]
	Residual	67.014	381	.176		
	Total	82.971	384			

a. Dependent Variable: TB risk reduction

b. Predictors: (Constant), Have you received training on TB Transmission Risk Reduction Measures (TB Infection Prevention and Control) i.e IPC on TB, It is important for every Healthcare Facility to have an official TB infection control policy, Have you received training on TB Transmission

Table 14. Coefficient of Variance

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	.416	.431		.964	.335
	It is important for every Healthcare facility to have an official TB infection control policy	.346	.425	.038	.813	.416
	Have you received training on TB Transmission	.193	.074	.207	2.621	.004
	Have you received training on TB Transmission Risk Reduction Measures (TB Infection Prevention and Control) i.e IPC on TB	.543	.073	.583	7.390	.000

a. Dependent Variable: TB risk reduction

Thus, based on the results of the descriptive and regression analyses, the Author can infer the following regarding the hypotheses:

Null Hypothesis (H0): There is no relationship between cues to action and self-efficacy of ADH healthcare workers (HCWs) with the practice of TB risk reduction measures.

The regression analysis indicates that the model is statistically significant ($F = 30.242$, $p = 0.000$), with the training on TB transmission risk reduction measures ($B = 0.543$, $p = 0.000$) being a strong predictor of TB risk reduction. This suggests that cues to action, such as training on TB transmission and infection prevention, significantly impact TB risk reduction practices. Therefore, based on these findings, **we would reject** the null hypothesis because the results demonstrate a clear relationship between training (a cue to action) and TB risk reduction measures.

Alternate Hypothesis (HA): There is a relationship between cues to action and self-efficacy of ADH HCWs with the practice of TB risk reduction measures.

The positive and significant regression coefficient for training on TB transmission risk reduction measures ($B = 0.543$, $p = 0.000$) strongly supports the alternate hypothesis. It implies that healthcare workers' self-efficacy, as influenced by the training they receive, positively affects their ability to practice effective TB risk reduction measures. Therefore, **we would accept** the alternate

hypothesis, as the analysis shows that cues to action, such as targeted training, are strongly associated with the effective practice of TB risk reduction.

Participant Observational Study (Spot Check)

Quantitative Study Results Using Structured Checklist

To assess TB risk of transmission and the TB risk reduction measures practices in the health care facility, the followings were revealed: all the 13 (100%) outpatient units it was observed that there is compliance to prompt identification and separation of TB suspects among other patients, only 7 units (54%) have available waiting areas for TB suspects, 9 (69%) units indicated that there is prompt diagnosis and commencement of treatment for TB confirmed cases, no unit (0%) has isolation ward for TB confirmed cases, just 2 units (16%) have a well-designed windows for effective natural ventilation, no unit (0%) has exhaust fans or ultraviolet germicidal irradiation (UVGI) fixtures, 6 units (46%) showed availability of N95 masks and 8 units (62%) indicated their prompt usage when need arises. Lastly, no unit (0%) has ever had Periodic provision of respirator fit test for HCWs before usage of N95 mask/FFP2. Table 15

In summary, the observation study revealed high risk of TB transmission and poor implementation of TB risk reduction measures.

Frequency Distribution

Table 15. TB Risk of Transmission and the TB Risk Reduction Measures Practices in ADH (Participants' Observational Study (Spot Check)

Categories	Yes	Percentage	No	Percentage
Prompt identification and separation of TB suspects among other patients	13	100%	0	0%
Availability of separate waiting area for TB suspects	7	53.8%	6	46.2%
Availability of prompt means of diagnosis of TB disease in TB suspect case	9	69.2%	4	30.8%
Prompt commencement of TB effective treatment to confirmed TB Cases among Patients/ HCWs	9	69.2%	4	30.8%
Availability of isolation ward for confirmed TB patients when need of admission is required	0	0%	13	100%
Presence of Natural ventilation (open windows on opposite sides)	2	15.4%	11	84.6%

Use of ventilation systems (Presence of exhaust fans)	0	0%	13	100%
Use of ultraviolet germicidal irradiation (UVGI) fixtures	0	0%	13	100%
Availability of N95 mask/FFP2 to HCWs	6	46.2%	7	53.8%
Periodic provision of respirator fit test to HCWs before usage of N95 mask/FFP2	0	0%	13	100%
Prompt usage of N95 mask/ FFP2 by HCWs when need arises	8	61.5%	5	38.5%

Discussion

Evidence – based studies affirmed that compliance of HCWs to TB risk reduction measures in health care facility is very important to prevent and control the risk of TB transmission in any health care facility [15, 30]. Nevertheless, HCWs behavioral inclination has a huge impact on how well HCWs would comply to TB risk reduction measures [15]. The study titled "Application of Health Belief Model; Tuberculosis in Healthcare Workers: Risk Reduction Measures at Asokoro District Hospital (ADH) Abuja FCT Nigeria" aims to assess the risk of TB transmission and the practice of TB risk reduction measures among HCWs using the HBM. The HBM is grounded on the constructs of perceived susceptibility, perceived severity, perceived barriers, perceived benefits, cues to action, and self-efficacy. These elements outline how individuals assess health risks and adopt preventive behaviors, which in this study, focus on the practice of TB risk reduction among HCWs in a high-burden health care facility.

Perceived Threats (Susceptibility and Severity) of TB Transmission

The results demonstrated a high level of awareness regarding the threat of TB transmission among HCWs in ADH. Almost all participants (87%) are aware that ADH is a TB high-burden health facility and 99% acknowledged that TB is highly infectious. The awareness of TB transmission routes, such as through laughing, singing, and talking, is also high among participants, indicating a strong perceived susceptibility to TB infection. This finding is in line with the studies conducted by [31, 32, 33]. Which revealed high risk of TB transmission among HCWs as a result of failure to compliance with TB – IPC measures especially in resource - limited facilities. The health belief model posits that individuals are more likely to engage in preventive behavior if one perceives a high risk of contracting a disease. In this case, the high awareness levels among participants suggest a heightened sense of susceptibility, which should theoretically drive stronger adoption of TB risk reduction measures.

Moreover, the study found that HCWs understood that TB bacteria could survive for extended periods in the air (up to six hours) and on surfaces (up to six months), reinforcing the perceived severity of the infection. These findings align with the HBM construct that perceived severity—understanding the seriousness of the disease and its potential

consequences—motivates individuals to adopt preventive measures. However, despite this awareness, barriers to practicing risk reduction measures persist among ADH HCWs.

Perceived Barriers Against TB Risk Reduction Measure Practices

The study identified significant barriers that hinder the practice of TB risk reduction measures among HCWs in ADH. The unavailability of N95 masks was expressed by 99% of participants as a key barrier, limiting their ability to fully protect themselves from TB disease/infection. Additionally, while 94% of participants agreed that using weak N95 masks or FFP2 could be sufficient in the absence of standard alternatives, this reflects a compromise in standard protective measures. Furthermore, the participant observational study discovered that there is no isolation and poorly designed building structure leading to lack of cross ventilation in most out patients units where patients converged in multiple numbers daily. These findings are consistent with the studies carried out in Dominican Republic by [34]. Similarly, it is in agreement with a systematic review that was conducted by [35] to discover the barriers and facilitators of tuberculosis infection prevention and control in low- and middle-income countries from the perspective of healthcare workers. Furthermore, a study conducted by [36] revealed similar barriers to be responsible for the poor TB risk reduction measures practice in most DOTS facilities in Nigeria. According to the HBM, perceived barriers which could be individualized like: low level of TB transmission threat or systemic such as: poor management involvement, would significantly impact the adoption of health behaviors. In this context, despite high level of perceived threat, the lack of adequate protective measures, no isolation unit, poor cross ventilation remain critical obstacles to the full implementation of TB risk reduction strategies in the health care facility.

Perceived Benefits of TB Risk Reduction Measures

The study also highlights the strong belief among HCWs in the effectiveness of TB risk reduction measures. Nearly all participants (98%) recognized the importance of using N95 masks to prevent TB transmission, and 89% agreed that surgical masks worn by TB patients could prevent the spread of TB bacteria. The belief in the effectiveness of environmental controls, such as keeping windows and doors open to prevent the spread of TB, was also prevalent (98%). These findings are consistent with the study conducted by [36,37].The HBM suggests that when individuals perceive significant benefits from preventive actions, they are more likely to adopt those behaviors. In this study, the high perceived benefits of using appropriate masks and maintaining cross ventilation align with the adoption of TB risk reduction practices. Therefore, to ensure their full implementation depends on the positive yielding of the management in addressing all the identified systemic barriers which will ultimately motivate HCWs adopting the TB risk reduction measures.

Cues to Action and Self-Efficacy with TB Risk Reduction Measures Practices

Cues to action, such as the availability of training and institutional policies are fundamental in promoting TB risk reduction measures practices. The study found that all participants (100%) agreed on the importance of preventing TB in healthcare facilities, and 55% had received training on TB transmission. While an official TB infection control policy was supported by most participants, the study revealed that simply having a policy is not enough to drive significant behavior change. The regression analysis demonstrated that training on TB transmission and TB infection prevention and control has strong positive effect on the practice of TB risk reduction measures ($B = 0.543$, $p = 0.000$), significantly more than the presence of a policy alone.

Self-efficacy, the confidence in one's ability to perform a behavior, is another critical HBM construct that is closely tied to cues to action. In this study, HCWs with higher levels of training on TB transmission risk reduction measures were more likely to adopt effective protective behaviors. This suggests that while awareness and perceived threats drive the intention to act, the actual adoption of risk reduction measures is heavily influenced by the availability of training and resources that build HCWs' confidence in their ability to protect themselves from TB disease/infection. The findings in this study is in line with the study conducted by [35] among HCWs on challenges in the implementation of TB – IPC in Mozambique. Similarly, [37,38,39,40] studies confirmed the importance of building HCWs capacity and having continuous mentorship as great instruments to successful TB risk reduction measures practice. Therefore, to every effort to build up HCWs capacity that will motivate the full implementation of TB risk reduction measures practice should be encouraged

Conclusion

Globally, TB remains an occupational health risk among HCWs, with the risk of transmission present throughout healthcare settings [41,42]. TB risk reduction measures is a combination of measures planned to reduce the risk of TB transmission within populations [13]. A declaration was made by [15] that HCWs behavioral inclination has a huge impact on how well they would comply to TB risk reduction measures practices [15]. Hence, this informed the decision of the Author utilizing HMB to assess the risk of TB transmission and TB risk reduction measures practices among HCWs in discovering their perceptions.

The study revealed both individualized and systemic related findings that are negatively affecting the full implementation of TB risk reduction measures in ADH: HCWs knowledge gap about TB mode of transmission, inadequate availability of protective equipment, limited training of HCWs on TB – IPC, lack of isolation unit and poor cross ventilation. On critical review of the study findings, it is crucial to point out that systemic related findings need to be addressed first because they have strong influence to alter the individualized inclined findings. This is because, the study has already revealed high levels of perceived threats of TB transmission risk and perceived benefits of the practice of TB risk reduction measures among ADH HCWs. These are individualized perceptions based on HMB usage which automatically would promote effective practice of TB risk reduction measures if positive systemic measures to motivate are well established within the system. Therefore, there is an urgent need of active involvement of the hospital management in all TB – IPC activities within the system. This is a critical requirement to tackle the findings in this study.

Limitation of the Study

One health care facility was utilized; in future other district health care facilities could be involved to ensure generalization of findings.

Recommendations

Based on the findings in this study, the followings are therefore recommended:

Active involvement of the hospital management in TB – IPC activities is crucial to the success of achieving full implementation of TB risk reduction measures within the health care facility since most findings are systemic inclined. Hence there is need to have TB – IPC committee with a designated professional to monitor and evaluate TB – IPC activities on daily basis, hospital - based TB – IPC policy should be developed as a guiding principle, budgetary allocation for TB – IPC activities should be given priority to ensure sufficient and constant supply of all required protective equipment, address the structural issues regarding poor ventilation and lack of isolation unit. Similarly, consistent periodic training of

all HCWs on TB – IPC measures to fill already identified HCWs knowledge gaps, opportunity for HCWs periodic TB screening is critical to protect all those working in highly risky unit within the health care facility, further research on TB – IPC involving more district health care facilities within the FCT to give room for multiple data collections and good generalization of findings.

Conflict of Interest

The study has been carried out with highest transparency and veracity, and no conflict of interest has been found

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The Impact of Fintech and Digital Platforms on Financial Inclusion in the Informal Sector of Ghana

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Abstract

Financial technology (fintech) is widely recognized as an effective tool to drive financial inclusion across the world. However, its impact on financial inclusion in the informal sector is yet to be understood especially in developing countries. This study assessed the impact of fintech and digital platforms on financial inclusion in the informal sector of Ghana. A descriptive cross-sectional research design was employed to select 365 participants in the informal sector from eight regions of Ghana through multistage sampling method for data collection. Data was collected using a 5-point Likert scale that was adapted with items to assess the role of fintech and adoption by people in the informal sector. After the data was analyzed with SPSS software version 23.0, it was a found that majority of participants took a neutral stance on the role and adoption of fintech; suggesting lack of awareness on fintech in the informal sector. The study can conclude that Ghana can benefit from the impact of fintech and digital platforms on financial inclusion in the informal sector through education and creation of awareness as there is lack of knowledge on fintech and its use in the sector.

Keywords: *Digital Platforms, Fintech, Ghana, Informal Sector.*

Introduction

Background of the Study

Fintech is a short form of 'Financial Technology' which is the application of information technology to provide financial services [1]. It is describes as a technology that is seeking to enhance the provision of financial services [2]. Fintech is associated with innovations such as electronic payment systems, digital banking applications, blockchain technology and artificial intelligence [3]. The main purpose of fintech is to promote efficiency, accessibility and innovation in financial services [4].

Fintech is contributing in diverse ways to transform the financial sector and has caused revolution in payment systems through platforms such as digital wallets, online payment gateways and payment applications that facilitate cashless transactions [5]. Fintech is also asserted as a disruptive innovation that affects the traditional financial sector which merely delivers through cash transactions and face-to-face exchanges between the service provider and customers [6]. Nonetheless, some have argued that fintech companies cannot replace the traditional banking sectors but has the advantage of engendering competition in the financial sectors by delivering efficient services with wider scope compared to the traditional financial sector [7]. It is in this context that this study sought to assess the impact of fintech on financial inclusion of the informal sector.

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Studies have shown that different factors drive fintech in different context. In attempting to provide insight into the contributing factors, the state, economic impacts and potential risk of financial technology in China, Hua and Huang [8] revealed that China's fintech development was driven by inadequate supply in formal financial sector, strong support of the government towards promotion of financial inclusion using digital technology and tolerant regulatory. Mobile money technology has also been identified as the main influencing factors for the adoption of fintech [9]. In india, ease of use and end-user habits positively affected the adoption of fintech [10]. Regardless of the factors driving the adoption of fintech in a particular context, its impact in economic development cannot be underestimated.

Studies on the impact of fintech have shown its role in access and utilization of financial services. Tarawali [11] examined the impact of fintech innovations on financial inclusion in low-income countries with focus on the level of access and usage of financial services and the barriers that prevent people from using the formal financial systems in Sierra Leone. The results of the survey indicated that 72% of the participants did not own account at a formal financial institution such as bank with 67% of the participants indicating that they had used mobile money services in the past one year. The study concluded that fintech has the potential to increase the number of people using financial services compare to the formal financial systems. In another study, it was found that fintech had the capacity to bring improvement and offer solutions to the existing challenges in the traditional financial sector [12]. Another study found that fintech has a facilitate role in third party, credits and insurance payments which have significant impact on economic growth [13]. In addition to economic growth, fintech serves as a transformational tool for entrepreneurship as it has the capacity to bring structural change in the traditional financial system [14].

Despite, the numerous studies on the role of fintech on financial inclusion and its impact on economic development, there is still limited knowledge on the impact of fintech and digital platforms on the financial inclusion in the informal sector of Ghana. This gap in knowledge if not addressed would undermine policy intervention in the sector and affect national development.

Problem Statement

The advent of fintech and digital platforms present opportunities to increase the level of financial inclusion in every economy [15]. However, the impact of these technologies on the informal sector in relation to financial inclusion is one problem that has not been well explored in research hence yet to be understood. The informal sector is broadly made up of micro, small and medium size business entities which are mostly operated outside government regulations [16]. Lack of finance to this group of businesses remains a major constraint that impedes their growth. Farazi [17] observed that operators within the informal sector hardly own bank accounts and access to bank loans among them is very low. This problem would likely contribute to prevent the growth of the sector and consequently affect its inputs to national economic development. While some operators of the informal sector may not desire to formally access financial services to support their businesses since they do not want to be taxed, the difficulty associated with accessing financial support from financial institutions is also a barrier that has prevented them from benefiting from formal financial services.

The emergence of fintech and digital platforms in recent years has the potential to bridge this gap by offering innovative financial solutions that are more accessible, cost-effective and tailored to the needs of the informal sector [18]. These solutions include mobile banking, digital payment systems, peer-

to- peer lending and micro-insurance, among others.

While a number of studies have been conducted to evaluate fintech and digital platforms from various angles, little attention has been paid to evaluating how these developments may affect the informal sector's financial inclusion. Among these studies include Odei-Appiah, Wiredu and Adjei [19] who looked into the effect of fintech usage on financial inclusion, Beck [20] investigated opportunities related to fintech, Makina [21] investigated the potential of fintech in financial inclusion in African countries, and Kandpal and Mehrotra [15] studied the role of fintech in digital financing in India. The existing body of research on fintech and financial inclusion suggests that little is known about how fintech affects financial inclusion in the informal sector of Ghana. The study was conducted to fill this knowledge gap by assessing the impact of fintech and digital platform on financial inclusion in the informal sector of Ghana.

Purpose of the Study

The main objective of the study was to assess the impact of fintech and digital platforms on financial inclusion in the informal sector of Ghana.

Limitation of the Study

Our study did not sample participants from all the categories of people operating in the informal sector. As a result, the findings cannot be generalized as the study recruited participants from some part of the informal sector. The interpretation of the study findings should therefore be done in the above given context.

Schematic Diagram

The schematic diagram shows the research process as in figure 1 below.

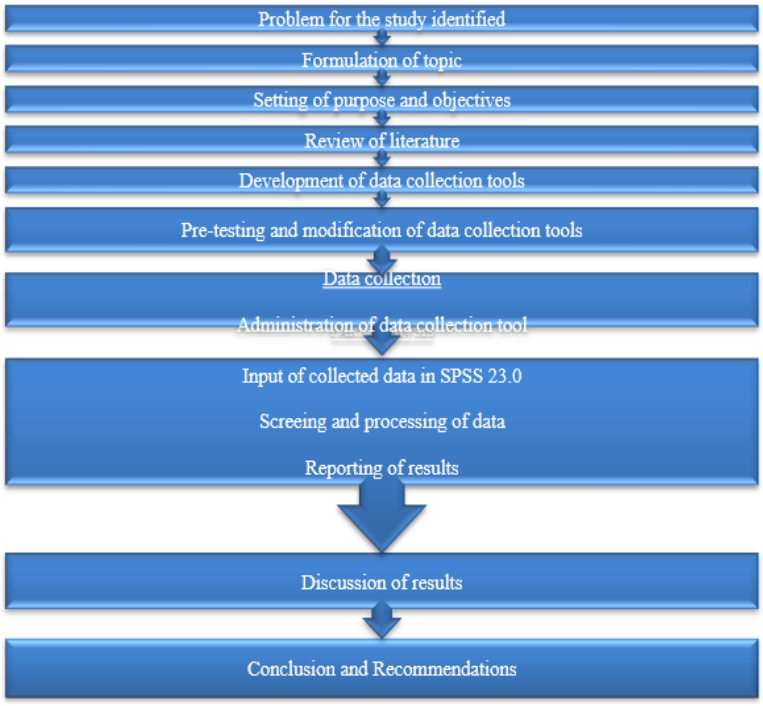

Figure 1. Schematic Diagram Showing the Research Process

Materials and Methods

Study Design and Setting

The study which used a descriptive cross-sectional design with quantitative approach was conducted in Ghana, a country in West Africa in the Sub-Saharan region. Ghana was originally known as the Gold Coast until it had independence from the British in 1957 [22]. With Accra as the capital town, Ghana is divided into 16 regions and has over 100 districts. It shares borders to the north with Burkina Faso and to the South with the Gulf of Guinea [23]. On the east, Ghana shares border with Togo and with Cote D'voire to the west [23]. Ghana has a total land area of 238,535 sq km and its population is estimated at 32.1 million according to the Ghana Statistical Service. With over 75 ethnic groups in the country the major languages spoken in Ghana include Dangme, Twi, Ewe, Ga, Dagbani, Dagaare among others.

Politically, Ghana is a democratic country that practices multiparty systems where elections are held every four years to elect a president and members of parliament. The president is the head of state and the executive arm of government. The other two arms of government are the Legislature and the Judiciary which are responsible for making and interpretation of laws respectively. Economically, Ghana is a developing country with over 50% of its population engaged in the informal sector activities [24]. It is endowed with mineral resources including gold, diamond, bauxite, timber, oil among others. In addition, Ghana has cash crops such as cocoa which is the major source of foreign exchange for the country.

In recent years, Ghana has embarked on a digitization agenda where the country is aiming to achieve a cashless economy [25]. This digitization drive in the country makes it a suitable setting to investigate the impact of fintech and digital platforms on financial inclusion of the informal activities. This study stands to provide insights into how the digitization agenda of the country is impacting majority of its population in the informal sector with regard to financial inclusion and consequently help to guide policy decisions in the country.

Study Population, Sampling and Sample Size

The population of this study consisted of all individuals in the informal sector of Ghana. The population is therefore an infinite population as the exact number of people in the sector is not known and cannot be counted due to the dynamics of the sector.

This study adopted a multistage sampling technique to select participants from the informal sector for data collection. With this method, the country (Ghana) was first clustered into 16 regions from which eight (8) regions were selected at random. Individuals working in informal sector were recruited at random to participate in the study. In all, a sample of 365 participants took part in the study.

Data Collection Tool and Procedure

This study was employed the use of a 5-point Likert scale to collect data for the study. The instrument consisted of six sections where the first part was designed to collect demographic information of participants. The remaining section of the instrument was focused to gather the opinions of participants in relations to the impact and adoption of fintech in the informal sector.

Study Population, Sampling and Sample Size

The population of the study was made up of operators in the informal sector which included farmers, artisans, block producers, transport operators, traders and casual labourers. A multistage sampling technique was used to select eight regions and six informal sectors in those regions for recruitment of participants. A sample of 365 participants was used for the study.

Data Analysis

The data for the study was analyzed using SPSS version 23 software. Prior to the analysis, each participant was given a unique code to avoid duplication of entries. The data was screened and all errors were removed to ensure accurate results. A descriptive analysis was performed were statistics such as mean, mode, median and standard deviation were determined for each item. The results were presented in tables with interpretations.

Results

The table 1 and 2 below shows the background information of participants and descriptive statistics respectively.

Table 1. Background Information of Participants

Variable	Frequency	Percentage (%)
Gender		
Female	189	51.8
Male	176	48.2
Total	**365**	**100.0**
Age		
18-25 years	39	10.7
26-33 years	45	12.3
34-41 years	111	30.4
42-49 years	140	38.4
50 or more years	30	8.2
Total	**365**	**100.0**
Highest education level		
Basic level	152	41.6
Secondary level	121	33.2
Tertiary level	92	25.2
Total	**365**	**100.0**
Religious background		
Christian	171	46.8
Muslim	142	38.9
Traditionalist	51	14.0
Total	**365**	**100.0**
Marital status		
Married	203	55.6
Single	162	44.4
Total	**366**	**100.00**
Occupation		
Artisan	21	5.8
Block producer	75	20.5
Casual laborer	11	3.0
Farmer	41	11.2
Trader	85	23.3
Transport operator	132	36.2
Total	**365**	**100.0**

Years of work		
Less than a year	21	5.8
1-3 years	50	13.7
4-7 years	140	38.4
8-11 years	121	33.2
12 or more years	33	9.0
Total	**365**	**100.0**
Region of residence		
Ashanti	83	22.7
Bono	72	19.7
Bono East	18	4.9
Central	14	3.8
Eastern	83	22.7
Greater Accra	63	17.3
Oti	15	4.1
Volta	17	4.7
Total	**365**	**100.0**

Table 2. Distribution of Participants' Response on the Impact of Fintech on Financial Inclusion

Code	Construct	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Impact of fintech on financial inclusion						
FIN1:	Fintech services have expanded my access to financial products and services	0 (0.0)	200 (54.8%)	6 (1.6%)	125 (34.2%)	32 (8.8%)
FIN2:	Fintech services have increased my ability to save and invest my money	232 (63.6%)	12 (3.3%)	95 (26.0%)	26 (7.1%)	0 (0.0)
FIN3:	Fintech adoption has made it easier for me to send and receive money	0 (0.0)	234 (64.1%)	3 (0.8%)	51 (14.0%)	77 (21.1%)
FIN4:	Fintech services have improved my ability to access credit and loans	0 (0.0)	215 (58.9%)	23 (6.3%)	104 (28.5%)	23 (6.3%)
FIN5:	Fintech services have reduced the time to access credit	0 (0.0)	215 (58.9%)	23 (6.3%)	104 (28.5%)	23 (6.3%)
FIN6:	Fintech services have increased awareness on financial products	0 (0.0)	215 (58.9%)	23 (6.3%)	104 (28.5%)	23 (6.3%)
FIN7:	Fintech services have improved my relationship with financial institutions	0 (0.0)	215 (58.9%)	23 (6.3%)	104 (28.5%)	23 (6.3%)
FIN8:	Fintech services have impacted me positively	0 (0.0)	215 (58.9%)	23 (6.3%)	104 (28.5%)	23 (6.3%)
Adoption of fintech in the informal sector						

FIS1	I am aware of fintech solutions in Ghana	0 (0.0)	223 (61.1%)	1 (0.3%)	108 (29.6%)	33 (9.0%)
FIS2	I have used a fintech solutions in the past year	0 (0.0)	219 (60.0%)	2 (0.5%)	62 (17%)	81 (22.2%)
FIS3	Fintech solutions are easy to use	0 (0.0)	248 (67.9%)	13 (3.6%)	79 (21.6%)	25 (6.8%)
FIS4	Fintech solutions are more convenient than traditional banking methods	194 (53.2%)	1 (0.3%)	63 (17.3%)	107 (29.3%)	0 (0.0%)
FIS5	I trust fintech solutions to keep my personal and financial information secure	210 (57.5%)	11 (3.0%)	125 (34.2%)	18 (4.9%)	1 (0.3%)
FIS6	I believe fintech solutions can help improve financial inclusion in Ghana	208 (57.0%)	1 (0.3%)	59 (16.2%)	97 (26.6%)	0 (0.0)
FIS7	Fintech solutions offer better interest rates and fees than traditional banks	0 (0.0)	170 (46.6%)	50 (13.7%)	98 (26.8%)	15 (4.1%)
FIS8	Fintech solutions offer transparency than traditional banks	0 (0.0)	170 (46.6%)	50 (13.7%)	98 (26.8%)	15 (4.1%)
FIS9	Fintech solutions have impacted financial inclusion	0 (0.0)	170 (46.6%)	50 (13.7%)	98 (26.8%)	15 (4.1%)

Discussion

The study examined the impact of fintech and digital finance in expanding financial services in the informal sector of Ghana. The finding showed that majority of participants indicated neutral responses on the role of fintech and digital finance in the expanding financial service in the informal sector. This finding suggests lack of awareness regarding the role of fintech and digital finance in the informal sector. Contrary to the results based on the studies that revealed that fintech and digital finance played a critical role in financial inclusion [12], [15], [26], [27], the current results showed that participants in the study lacked knowledge about fintech and digital finance thus highlighting the need for effective education and orientation on fintech for people in the informal sector. This further supports the finding made by an earlier study by Coffie [28] that promotion of fintech in driving financial inclusion in Ghana depends on government regulations and building of infrastructure. The use of regulation and having adequate fintech infrastructure and effective awareness creation can significantly impact financial inclusion among people especially in the informal sector. Furthermore, the result can also be due to mixed experience of participants on fintech and digital finance that led to their neutrality. The finding implies that there are underlying barriers to the adoption of fintech and digital finance in the informal sector which should be addressed through engagement and education by financial institutions with people in the sector. The outcome also calls for attention of researchers to carry out qualitative studies to understand the reasons for the expressing of neutrality by people in the informal sector on fintech and digital finance.

In all, the outcome of the study presents a general lack of clear position of participants on

the role of fintech and digital finance in expanding financial services. This revelation can be attributed to lack of knowledge or awareness as well as mixed experiences on fintech and digital finance on the part of people in the informal sector.

The study also sought to assess the state of adoption of fintech solutions in the informal sector of Ghana. The outcome of the study showed that majority of the participants lacked understanding with regard to fintech solutions as they took a neutral stand on the items used for the assessment. This means that there is uncertainty about the adoption of fintech solutions in the informal sector. The result is not consistent with the outcome of previous studies where there was adoption of fintech in various sectors [29], [30]. As found by Broni and Owusu [31] where lack of awareness, skills and regulatory frameworks served as barriers to the adoption of fintech solutions, the current results could be due to lack of literacy as majority of people in the informal sector of Ghana have low education background which limits their ability to adopt fintech solutions. This neutrality stance could also be attributed to fear for use of new technologies among people in the informal sector due to lack of trust and confidence. The finding is relevant as it underscores the need for stakeholders to create supportive frameworks that would encourage the adoption of fintech solutions in the informal sector.

Equations

The sample size for the study was calculated using the Cochran's formula as follows;

Sample size (n) = $z^2 \frac{pq}{e^2}$ (1)

Where

Z = Z-score value at 95% confidence interval = 1.96

P = proportion of the people in the informal sector (65.3% of labour force are in the informal sector as estimate by Ghana Statistical Service) = 65.3% = 0.653

q = 1-p = 1- 0.653 = 0.347

e = Margin of error = 5% = 0.05

Substituting the above values into equation 1;

Sample size (n) = $1.96^2 \frac{(0.653)(0.347)}{0.5^2}$

$(0.347)/0.05^2$

= 0.8705/0.0025

= 348

The sample size was increased by 10% to cater for errors and omission that could arise in the data. This yielded an estimated sample size of 383.

Conclusion

In conclusion, the study established that there is no significant impact of fintech on the financial inclusion of people in the informal sector of Ghana. This outcome can be attributed to factors including lack of awareness or mixed-feeling among participants regarding the role of fintech in financial inclusion. This insight is significant and demand attention on the part of fintech firms to create awareness on fintech and how it can impact on financial inclusion in the informal sector.

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Conflict of Interest

We declare that there is no conflict of interest in the conduct of this study.

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Current State of Financial Inclusion in the Informal Sector of Ghana

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Abstract

Financial inclusion has emerged as a concept that is of global concern in the domains of financial expansion, policy and all-encompassing prosperity. As a result, many countries have embraced the concept as a key driver of development agenda. However, knowledge of the state of financial inclusion in the informal sector is limited especially in developing countries. The purpose of this study was to assess the state of financial inclusion in the informal sector of Ghana. The study was descriptive and cross-sectional which employed multistage sampling to select 365 participants in the informal sector from eight regions. Data was collected using a 5-point Likert scale which reliability was achieved by ensuring all items scored Cronbach Alpha value of above 0.7. Descriptive analysis of the data was conducted using Statistical Package for Social Science (SPSS) version 23 software. The results of the study showed that there is lack of accessibility, quality and usage of financial services and products in the informal sector of Ghana. In conclusion, the study findings highlight the need to improve the state of financial inclusion in the informal sector to enhance the participation of people in the sector in the national development agenda.

Keywords: *Financial Inclusion, Ghana, Informal Sector, State.*

Introduction

Background of the Study

According to the World Bank, financial inclusion refers to the state where individuals and business entities get access to financial products and services that are useful and affordable, and which meet their needs in relation to transactions, payments, savings, credit and insurance in a manner that is responsible and sustainable [1]. In recent years, financial inclusion has emerged as a concept that is of global concern in the domains of financial expansion, policy and all-encompassing prosperity. Many countries are now embracing the concept with the objective of promoting their development agenda. The World Bank sees financial inclusion as the effective means by which countries can achieve at least some of the Sustainable Development Goals (SDGs) [2]. These goals include SDG1 that specifically aims to end extreme poverty [3], in which financial inclusion would contribute to providing financial support in education and business which can impact on agricultural activities and consequently help to reduce hunger as stipulated in SDG2 [4]. With the reduction in hunger, this could positively impact on health and the well-being of people which the SDG3 is seeking to achieve [5]. Furthermore, increase in financial inclusion has the tendency to empower women to have financial control and this can promote gender equity as targeted in SDG5 [6]. Again, the World Bank believes that by improving financial access, it is possible to drive business

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innovation as expected by SDG9 [7]. It has also been suggested that financial inclusion would also help to reduce inequality within countries; the results that the SDG10 is expected to achieve [8] [9]. Nonetheless, until the recent past, the global statistics of people who had access to financial services and products were limited.

It is estimated that 69% of adults around the world had bank accounts in 2017; a situation that represented an increase from 51% in 2011. Similarly, access to Automated Teller Machines (ATM) per 100,000 adults worldwide increased from 41.6% to 53.5% in 2017. According to the Global Findex Database, the population in Sub-Saharan Africa (SSA) that possessed bank account increased from 43% in 2017 to 55% in 2021; a figure that is far below the global average of 76% [1]. With approximately 21% of the adult population in SSA who possess mobile money account, financial inclusion in era of technology needs to be examined especially within the informal sector [10]. Although, there are significant strides in promoting financial systems and inclusion among some African countries, there is still considerable need for efforts to achieve overall financial inclusion especially those in the informal sector.

Problem Statement

In developing countries, the informal sector has been recognized as a major source of employment and means of subsistence [11]. The Alliance for Financial Inclusion (AFI) estimates that 89.9% of workers in low-income countries are in the informal sector while 83.7% and 52.6% of workers in lower-middle income and upper-middle income countries are respectively in the informal sector [12]. Following its role in providing jobs, the sector is a key contributor to income generation and a channel for creating wealth as well as facilitating incubation of business innovations and creativity [13]. Emphasizing on the importance of the informal sector in national growth and development, Delechat and Medina [14], indicate that it accounts for about one-third of Gross Domestic Product (GDP) in developing economies. However, the informal sector in most developing countries continue to suffer financial exclusion; a phenomenon that negatively impacts its growth and contribution to national development.

Purpose of the Study

The main purpose of the study was to assess the current state of financial inclusion in the informal sector of Ghana.

Limitations

Our study did not sample participants from all the categories of people operating in the informal sector. As a result, the findings cannot be generalized as the study recruited participants from some part of the informal sector. The interpretation of the study findings should therefore be done in the above given context.

Schematic Diagram

The schematic diagram shows the research process as in figure 1 below.

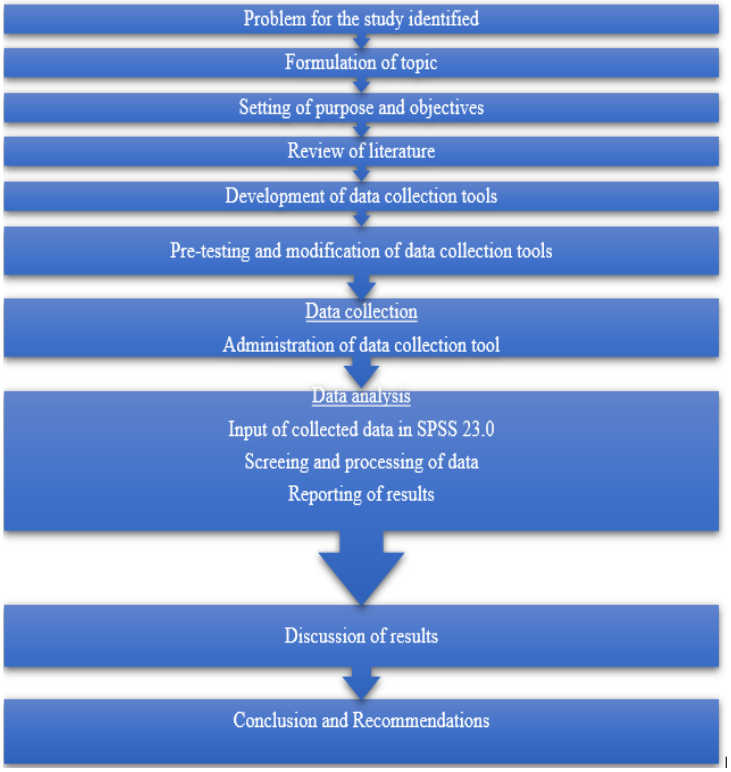

Figure 1. Schematic Diagram Showing the Research Process

Materials and Methods

Study Design and Setting

The study which used a descriptive cross-sectional design with quantitative approach was conducted in Ghana, a country in West Africa in the Sub-Saharan region. Ghana was originally known as the Gold Coast until it had independence from the British in 1957 [15]. With Accra as the capital town, Ghana is divided into 16 regions and has over 100 districts. It shares borders to the north with Burkina Faso and to the South with the Gulf of Guinea [16]. On the east, Ghana shares border with Togo and with Cote D'voire to the west [16].

Ghana has a total land area of 238,535 sq km and its population is estimated at 32.1 million according to the Ghana Statistical Service. With over 75 ethnic groups in the country the major languages spoken in Ghana include Dangme, Twi, Ewe, Ga, Dagbani, Dagaare among others.

Politically, Ghana is a democratic country that practices multiparty systems where elections are held every four years to elect a president and members of parliament. The president is the head of state and the executive arm of government. The other two arms of government are the Legislature and the Judiciary which are responsible for making and interpretation of laws respectively.

Economically, Ghana is a developing country with over 50% of its population engaged in the informal sector activities [17]. It is endowed with mineral resources including gold, diamond, bauxite, timber, oil among others. In addition, Ghana has cash crops such as cocoa which is the major source of foreign exchange for the country.

In recent years, Ghana has embarked on a digitization agenda where the country is aiming to achieve a cashless economy [18]. This digitization drive in the country makes it a suitable setting to investigate the impact of fintech and digital platforms on financial inclusion of informal activities. This study stands to provide insights into how the digitization agenda of the country is impacting

majority of its population in the informal sector with regard to financial inclusion and consequently help to guide policy decisions in the country.

Study Population, Sampling and Sample Size

The population of this study consisted of all individuals in the informal sector of Ghana. The population is therefore an infinite population as the exact number of people in the sector is not known and cannot be counted due to the dynamics of the sector.

This study adopted a multistage sampling technique to select participants from the informal sector for data collection. With this method, the country (Ghana) was first clustered into 16 regions from which eight (8) regions were selected at random. Individuals working in the informal sector were recruited at random to participate in the study. In all, a sample of 365 participants took part in the study.

Data Collection Tool and Procedure

This study employed the use of a 5- point Likert scale to collect data for the study. The instrument consisted of six sections where the first part was designed to collect demographic information of participants. The remaining section of the instrument was focused on gathering the opinions of participants in relations to access, usage and quality of financial services or products in the informal sector.

Study Population, Sampling and Sample Size

The population of the study was made up of operators in the informal sector which included farmers, artisans, block producers, transport operators, traders and casual labourers. A multistage sampling technique was used to select eight regions and six informal sectors in those regions for the recruitment of participants. A sample of 365 participants was used for the study.

Data Analysis

The data for the study was analyzed using SPSS version 23 software. Prior to the analysis, each participant was given a unique code to avoid duplication of entries. The data was screened, and all errors were removed to ensure accurate results. A descriptive analysis was performed were statistics such as mean, mode, median and standard deviation were determined for each item. The results were presented in tables with interpretations.

Results

The table 1 and 2 below show the background information of participants and descriptive statistics respectively.

Table 1. Background Information for Participants

Variable	Frequency	Percentage (%)
Gender		
Female	189	51.8
Male	176	48.2
Total	**365**	**100.0**
Age		
18-25 years	39	10.7
26-33 years	45	12.3
34-41 years	111	30.4
42-49 years	140	38.4
50 or more years	30	8.2

Total	**365**	**100.0**
Highest education level		
Basic level	152	41.6
Secondary level	121	33.2
Tertiary level	92	25.2
Total	**365**	**100.0**
Religious background		
Christian	171	46.8
Muslim	142	38.9
Traditionalist	51	14.0
Total	**365**	**100.0**
Marital status		
Married	203	55.6
Single	162	44.4
Total	**366**	**100.00**
Occupation		
Artisan	21	5.8
Block producer	75	20.5
Casual laborer	11	3.0
Farmer	41	11.2
Trader	85	23.3
Transport operator	132	36.2
Total	**365**	**100.0**
Years of work		
Less than a year	21	5.8
1-3 years	50	13.7
4-7 years	140	38.4
8-11 years	121	33.2
12 or more years	33	9.0
Total	**365**	**100.0**
Region of residence		
Ashanti	83	22.7
Bono	72	19.7
Bono East	18	4.9
Central	14	3.8
Eastern	83	22.7
Greater Accra	63	17.3
Oti	15	4.1
Volta	17	4.7
Total	**365**	**100.0**

Table 2. Descriptive Statistics of Participants' Response on Access, Quality and Usage of Financial Services/ Products

Constructs	Median	Mode.	Mean	Std. Deviation	Interpretation of mean
Access to financial services/products					
ACC1: There are many financial service delivery channels available nearby.	2.00	1	1.98	0.98	Disagree
ACC2: There are many financial institution branches located nearby.	1.00	1	1.79	0.93	Strongly disagree
ACC3: The initial opening fees charged by the financial institutions are affordable.	1.00	1	1.68	0.92	Strongly disagree
ACC4: The maintenance fees charged by financial institutions are affordable.	2.00	1	1.88	0.91	Disagree
ACC5: The minimum balance required for savings accounts is affordable.	2.00	2	2.74	0.96	Neutral
ACC6: The loan fees charged by financial institutions are satisfactory.	2.00	1	1.91	0.95	Disagree
ACC7: The minimum loan amounts offered by financial institutions are satisfactory.	2.00	1	1.91	0.95	Disagree
ACC8: The number of documents required to open an account is minimal.	2.00	1	2.00	0.99	Disagree
ACC9: The time taken to process loan application is favourable.	3.00	2	2.97	1.00	Neutral
ACC10: I do not experience discrimination from financial institutions in their service provision.	2.00	1	1.96	1.10	Disagree
ACC11: The location for submitting loan applications is convenient.	1.00	1	1.71	0.95	Strongly disagree
ACC12: The fees charged for payment services by financial institutions are affordable.	2.00	1	1.97	0.99	Disagree
ACC13: All charges by financial institutions are affordable.	2.00	1	1.97	0.99	Disagree
ACC14: I can access the services by financial institutions.	2.00	1.00	1.96	0.97	Disagree
ACC15: I can access the products by financial institutions.	2.00	2.00	1.96	0.95	Disagree
Quality of financial services/products					
QTY1: The savings product provided by the financial institutions suits our needs	2.00	2	2.48	0.92	Disagree

QTY2: The loan products provided by the financial institutions suits our needs	2.00	2	2.63	0.95	Disagree
QTY3: The payment services provided by the financial institutions suits our needs	1.00	1	1.53	0.96	Strongly disagree
QTY4: The savings products provided by the financial institutions is safe for us	2.00	2	2.69	0.97	Neutral
QTY5: The loan product provided by the financial institution is safe for us	1.00	1	1.64	1.00	Strongly disagree
QTY6: The payment services provided by the financial institution is safe for us	2.00	2	2.66	1.00	Neutral
QTY7: The savings product provided by the financial institution satisfies us	1.00	1	1.56	0.97	Strongly disagree
QTY8: The loan product provided by the financial institutions satisfies us	1.00	1	1.74	0.98	Strongly disagree
QTY9: The payment services provided by the financial institutions satisfies us	1.00	1	1.60	0.97	Strongly disagree
QTY10: The savings product provided by the financial institutions is useful to us	2.00	2	2.44	0.87	Disagree
QTY11: The loan products provided by the financial institution is useful to us	2.00	2	2.56	0.96	Disagree
QTY12: The payment services provided by the financial institution is useful to us	2.00	2	2.51	0.96	Disagree
Usage of financial services/products					
USG1: The cost of making trip to financial institutions is low	1.00	1	1.90	1.02	Disagree
USG2: The paper work requirements by the financial institution is favourable	2.00	1	1.92	0.92	Disagree
USG3: The fees charged by the financial institution on use of its services are favourable	2.00	1	2.04	0.95	Disagree
USG4: The level of service provision by the financial institutions in very good	2.00	1	1.96	1.00	Disagree
USG5: The financial institution is always providing its services on regular basis	2.00	2	2.67	1.01	Neutral
USG6: The financial institution always provides it financial services at convenient hours	1.00	1	1.63	0.96	Strongly disagree
USG7: Workers in this sector trust financial products and services offered by the financial institutions	2.00	1	2.03	1.05	Disagree
USG8: The products and services provided by the financial institution are user friendly	2.00	2	2.67	0.92	Neutral

USG9: The process of getting financial services from the financial institutions is easy	3.00	2	3.00	1.05	Neutral
USG10: It takes us less time to reach the financial to get the services	2.00	2	2.65	0.95	Neutral
USG11: The interest on deposit services offered by the financial institution is attractive for us	2.00	1	2.51	1.47	Disagree
USG12: The terms set by the financial institutions on use of its products and services are favourable to us	1.00	1	1.66	0.96	Strongly disagree
USG13: The terms of repayment of loans provided by the financial institution is favourable to us	1.00	1	1.62	0.91	Strongly disagree
UGG14: I have used the services of financial institutions.	1.00	1	1.62	0.91	Strongly disagree

Discussion

The study sought to assess the current state of financial inclusion in the informal sector of Ghana. The study found that there is no significant access to financial services and products among people in the informal sector. The finding is not consistent with the results by previous studies where the advent of mobile money and other digital platforms were found to impact accessibility to financial services and products by people who hitherto were left out in the formal financial systems [10], [19], [20]. It however implies that people in the informal sector have not proven to be trusted by financial institutions to be given financial products. On the other hand, lack of credibility in the informal sectors can be attributed to their lack of access to financial services and products. The results can also be attributed to lack of financial literacy among people in the informal sector which serves as a barrier to access of financial products from financial institutions. As posited by Gunarsih, Sayekti and Dewanti [21], access to financial services and products by individuals or business entities is essential for economic growth. The outcome is therefore significant as it calls for financial institutions to improve access to the informal sector by education for people in the sector about their services and products as suggested by Myeni, Makate and Mahonye [22] that targeted education programs can contribute to improve financial inclusion.

The results of the study also showed that there is no quality or relevance of financial services and products for people in the informal sector of Ghana. This result was different from the findings of previous studies which largely established the quality of financial services and products to underserved population such as the informal sector [23]. This means that financial services and products are perceived not to serve purpose for the people operating in the informal sector and hence raises concern about how the sector can achieve expected growth. The situation can be attributed to lack of tailored services and products by financial institutions for those in the informal sector. In other words, unfavorable terms and conditions regarding financial products that do not give flexibility for the informal sector would defeat its usefulness to operators in the sector. The result is a call for stakeholders in the financial sector to design

financial products in line with the needs of people in the informal sector.

The study also found that there was no significant usage of financial services and products in the informal sector. While the result is inconsistent with previous findings[19], it has implications for limited capital for businesses in the informal sector which affect growth and development in the sector. The finding also means that people in the informal sector risk the opportunities to build credit worthiness that would facilitate their access to bigger loans and other financial products. This would consequently limit growth and affect government revenue mobilization in the informal sector. The finding highlights the needs for financial institutions to encourage the informal sector to use financial services. The finding is also a call to further investigate the factors that influence utilization of financial services among people in the informal sector.

In short, the outcome of the study has revealed that there is lack of access, quality of financial products and services as well as usage of financial services and products in the informal sector. As a result, the study finding is a call for a paradigm shift on the operations of financial institutions that would contribute to accessibility, quality and usage of financial services and products in the informal sector.

Equations

The sample size for the study was calculated using the Cochran's formula as follows.

Sample size (n) $= = z^2 \frac{pq}{e^2}$ (1)

Where,

Z = Z-score value at 95% confidence interval = 1.96

P = proportion of the people in the informal sector (65.3% of labour force are in the informal sector as estimate by Ghana Statistical Service) = 65.3% = 0.653

q = 1-p = 1- 0.653 = 0.347

e = Margin of error = 5% = 0.05

Substituting the above values into equation 1.

Sample size (n) $== 1.96^2 \frac{(0.653)(0.347)}{0.5^2}$

= 0.8705/0.0025

= 348

The sample size was increased by 10% to cater for errors and omission that could arise in the data. This yielded an estimated sample size of 383.

Conclusions

The study has established the state of financial inclusion in the informal sector of Ghana. According to study, there is no significant access, quality and usage of financial services and products among operators in the informal sector. This outcome of the study has implications for the growth of the informal sector and its overall contribution to the development of Ghana. It is therefore relevant as it serves as a basis for stakeholders to improve the state of financial inclusion in the informal sector.

Acknowledgement

We would like to thank all the participants for their consent and voluntary participation in the study.

Conflict of Interest

We declare that there is no conflict of interest in the conduct of this study.

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Prevalence of Breast Cancer in First Time Patients Visiting the Federal Medical Centre, Abuja, Nigeria

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Abstract

Breast cancer, which is the most common malignant disorder affecting women, is characterized by the abnormal growth of cells in the breast. The study examined the burden of breast cancer in the Federal Medical Centre, Abuja, Nigeria. A sample of 300 women was taken from a population consisting of women between the ages of 18-75 years who were visiting the hospital for the first time for a period of six months. Patients were reviewed using predesigned questionnaires which focused on socio-demographic information and clinical information. The study employed statistical tools of Chi-Square and the Duncan Multiple Range test to analyse data. From a total of 300 patients screened, 65% of the studied population had grade II breast cancer while 35% had grade III breast cancer, while the most frequent histological feature observed was the invasive ductal carcinoma with 76.3% and invasive ductal carcinoma with lymphovascular invasion represented 23.7 %. The result from this study also showed that 56.4 % of the population had cancer on the right breast while 43.6 % had cancer on the left breast and 66.7 % of the cancer patients were diagnosed through trucut biopsy, 21.2 % though excision while 12.1 % was through incision technique. The findings of this study serves as a guide to health practitioners and educators in the design and execution of campaign towards oncological studies and advocates for greater public health initiatives, including education on early detection and better healthcare infrastructure, to combat the rising burden of breast cancer in Nigeria.

Keyword: *Abuja, Awareness, Breast cancer, Prevalence, Risk factors.*

Introduction

Breast cancer, which is the most common malignant disorder affecting women, is characterized by the abnormal growth of cells in the breast [1]. It was reported in 2020 to be the fifth leading cause of cancer death globally with 685,000 deaths associated with it [2]. Although it occurs in women of all races, however, discrepancies occur in diagnosis, mortality, and survival [3]. Incidence of breast cancer has been reported mostly in developed countries than in developing countries [4]. Notwithstanding, the incidence is increasing in developing countries like Nigeria, with many cases diagnosed at advanced stages, particularly stages III and IV, where treatment options are more limited, and outcomes are poorer.

Breast cancer is quite familiar among premenopausal women in Nigerian, with cases typically occurring around an average age of 48. In Western Africa, Nigeria has been reported to have the highest breast cancer incidence rate at 50.5 cases per 100,000 women and an age-standardized mortality rate of 25.9 per 100,000. Data obtained from recent studies show that breast cancer represents about 22.7% of all cancer cases among Nigerian women, with an estimated 140,000 new cases annually, highlighting its high prevalence relative to other types of cancer in the country [5]. In the Abuja population-based cancer registry, breast cancer accounts for 55.6% and 45.7% among women

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younger than 45 years and women aged 45 years and older [6]. A recent sub-Saharan African multinational study by [7] found that patients with breast cancer in Nigeria had the lowest three-year survival rate (36%) compared to 44% in Uganda, 47% in Zambia, 56% for Black women in Namibia and 59% for Black women in South Africa. While the outcomes remain low due to late presentation, the increase of breast cancer in Nigeria may be influenced by late-stage diagnosis, lack of awareness about early detection methods, and limited access to treatment options like immunohistochemistry, chemotherapy, and radiotherapy, which also lead to an increased mortality rate among affected women [8].

Several non- modifiable risk factors such as age, gender, family history, breast density and genetic factors have been reportedly associated with breast cancer [9]. Many reports have focused on patient-related and health system challenges from symptom development through to diagnosis in Hospital facilities in some parts of Nigeria but none has been reported in Federal Medical centre, Abuja. Hence, it is therefore imperative to identify how the incidence and mortality rate of the disease can be reduced by ascertaining its prevalence.

The objective of this study was to determine the prevalence of women with breast cancer in Federal Medical Centre Abuja, Nigeria by generating data on breast cancer among female attendees.

Materials and Methods

Study Area

The current study was conducted in the Oncological ward in Federal Medical Centre, Abuja, Nigeria. The choice of facility was informed by their size, volume, proximity of service to people and the geographical locations.

Study Design

The study was a descriptive, cross-sectional design and a total number of 300 female patients aged 18-75 years participated. The age group was chosen because a previous study by [10], reported this age bracket to be more affected in risk assessment. The study was carried out over a period of six (6) months between April and October, 2023 with well-structured questionnaires with both open and closed ended question administered to patients attending Oncological ward in Federal Medical Centre, Abuja.

Ethical Considerations

Ethical approval was obtained from the Health Research and Ethics Committees, Federal Ministry of Health, Abuja. The study was conducted according to the principles of the Declaration of Helsinki while informed consent was sought from every participant before undertaking to participate in the study.

Demographic and Clinical Information

Demographic and clinical information were obtained from questionnaires completed by patients, which include patient's gender, marital status, age, education (primary, secondary, diploma, University, post graduate), employment status (unemployed/employed), type of cancer and stage of cancer.

Participants were questioned about their past medical history including: parity, first symptom, menopausal status and duration of illness. Risk factors such as the use of alcohol, smoking, family history, use of contraceptive, lactation and previous history of benign breast lesions were also extracted. Body mass index (BMI) of each patient was estimated by taking the height and weight of participants and a BMI of 30 kg/m^2 or more was defined as obesity and 25 kg/m^2 or more was considered overweight [11].

Data Analysis

Data obtained were analysed using the Statistical Package for the Social Sciences (IBM SPSS Incorp., Illinois, Chicago, USA) version 27 for Windows. Univariate analyses were presented in the forms of descriptive

frequency distribution of the socio-demographic. Association analyses were conducted using Chi-squared and analysis of variance (ANOVA) with Statistical significance set at P<5% level.

Results

Distribution of Breast Cancer Patients with Respect to Grade

From a total of 300 patients screened, Figure 1 illustrates that 65% of the studied population had grade II breast cancer while 35% had grade III breast cancer with statistical significance of (χ^2 = 3.60, *P* = 0.058).

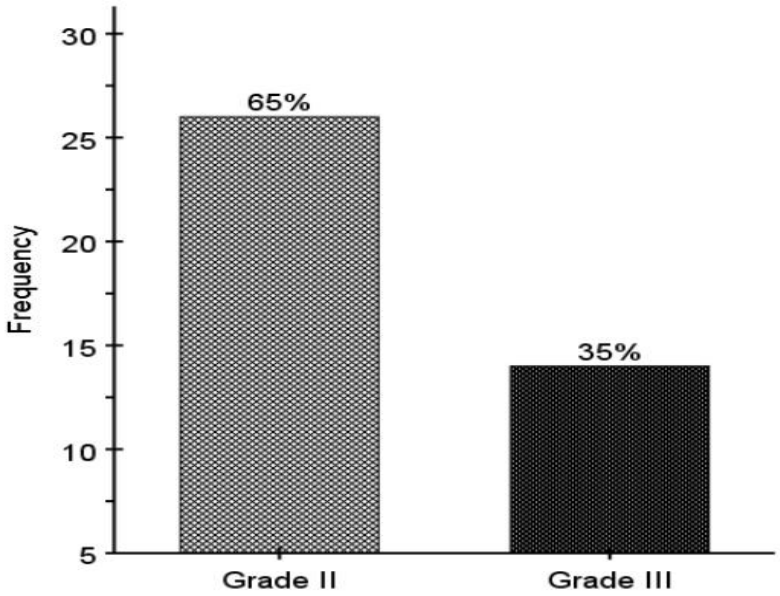

Figure 1. Distribution of Cancer Grade

Distribution of Breast Cancer Patients with Respect to Histological Characteristic

Figure 2 shows that the most frequent histological feature observed was invasive ductal carcinoma with 76.3% while invasive ductal carcinoma with lymphovascular invasion represented 23.7 % (χ^2 = 10.53, *P* <0.001) of studied population with breast cancer.

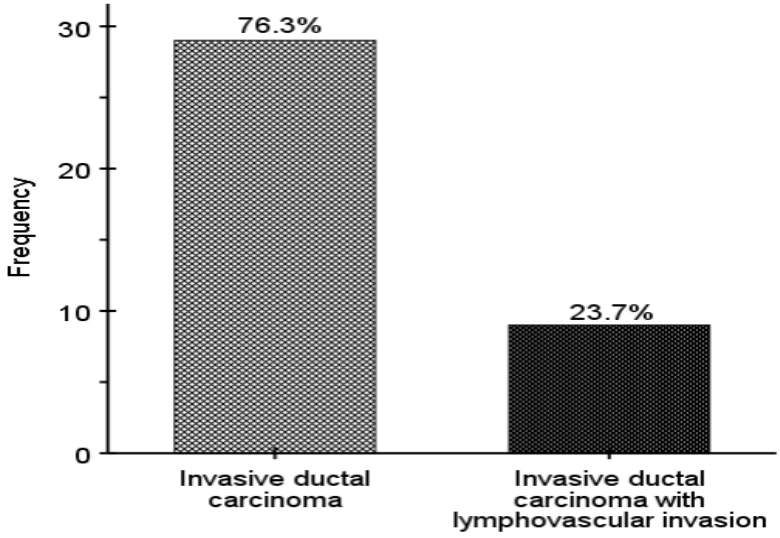

Figure 2. Distribution of Histological Characteristics of Cancer

Distribution of Breast Cancer Patients with Respect to Breast Position

The result from this study showed that 56.4 % had cancer on the right breast while 43.6 % had cancer on the left breast as shown in Figure 3. There was no statistical significance in the distribution of cancer on either the left or right breast ($\chi^2 = 0.64$, $P = 0.423$).

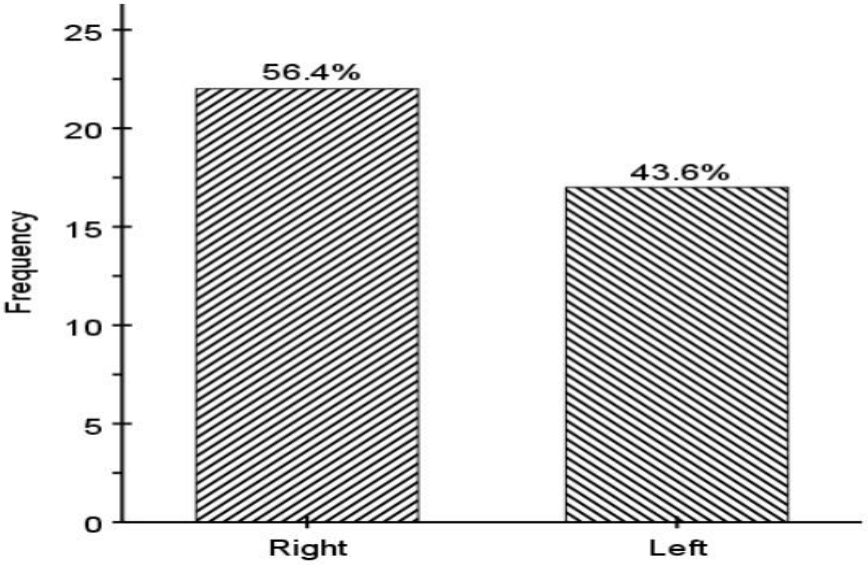

Figure 3. Distribution of Breast Cancer Position

Distribution of Breast Cancer Patients with Respect to Biopsy Technique

The result from this study in Figure 4 shows that 66.7 % of the cancer patients were diagnosed through trucut biopsy, 21.2 % though excision while 12.1 % was through incision technique. There was statistical significance in the distribution of cancer between all three diagnostic techniques ($\chi^2 = 16.91$, $P < 0.001$).

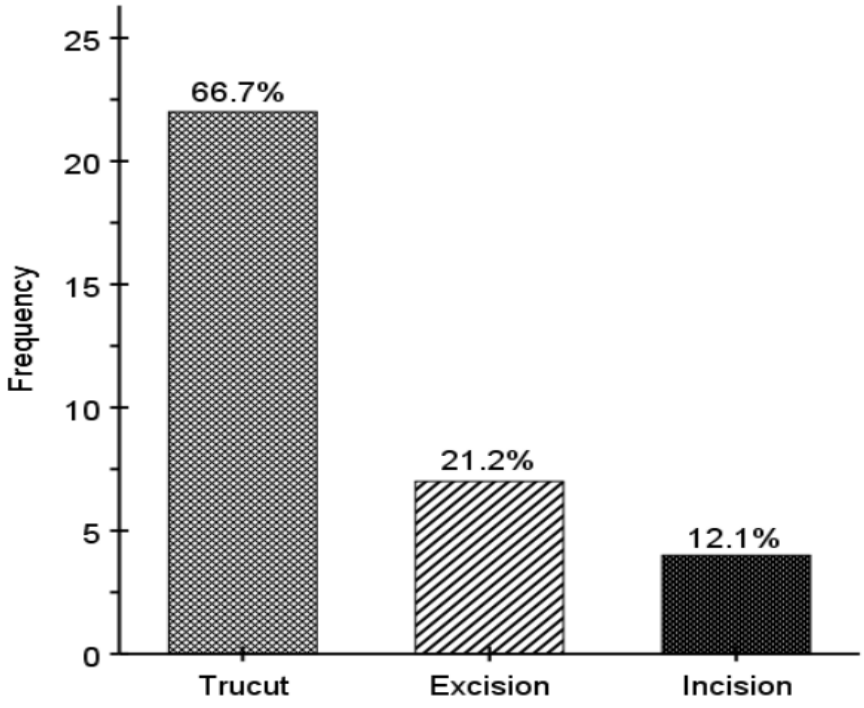

Figure 4. Distribution of Biopsy Procedure in Patients with Breast Cancer

Discussions

It has been frequently reported that grade II breast cancer is more prevalent compared to other grades of breast cancer [11]. In similar research carried out by [11] in Radiotherapy Unit of Lagos University Teaching Hospital, Idi-Araba, Nigeria, 52.6 % of the population sampled were diagnosed with grade II breast cancer while 31.5 % had grade III breast cancer. A reason why the grade II is more often reported could be as result of the cancer not fast growing and spreading, looking like normal breast cells [12]. Hence, patients most times start to notice the symptoms visibly in the second grade and then go for breast examination.

Globally, the invasive ductal carcinoma is the commonest histologic subtype of breast cancer reported [13, 14, 15]. Similarly, in another study by [16], it was reported that 51.9 % and 48.1 % presented invasive ductal carcinoma in both the left and right breast respectively. Findings in this study corroborates previous reports as cancer patients in this study represents 76.3% of the breast cancer patients examined. Lymphatic invasion which is the presence of tumour emboli lymphatic vessels or blood capillaries without underlying smooth muscle and elastic fibres has been reported to be a predictor of worse prognosis in patients with invasive ductal carcinoma of the breast [17].

The reason why most of the studied population had more of invasive breast cancer, may have been driven by hormones, or hormone (estrogen/progesterone) receptor (HR)–positive [17]. Quite a number of reported cases have HER2-positive and HR-negative, implying that the cancer cells make a higher-than-normal amount of the HER2 protein, which facilitates tumor growth.

In a study published by [18], it was suggested that breast cancer is slightly more common in the left breast than in the right. Similarly, The National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program also corroborated this finding, where according to the data obtained of more than 881,000 people with breast cancer, 50.8% of breast cancers occurred on the left side compared to 49.2% on the right. All these reports contradict with the current study which recorded a higher number of breast cancer on the right breast 56.4% compared to the left 43.6%.

A possible reason why most of the previous studied population had cancer on the left breast than on the right may be because of factors like breast size and density and breast feeding [19]. Most people reportedly breastfeed with their right breast hence making the left breast to retain breastmilk more thereby reducing the protective effect of breastfeeding in the left breast [20, 21]. Contrary to this assumption, majority of Nigerians are right handed and this translates that they automatically breast feed the children more on the left breast while the right breast continues to retain milk, this could be the reason for more manifestation of the breast cancer on the right breast.

Tru-cut needle biopsies form an essential part of Triple assessment of breast cancer which encompasses clinical assessment, mammography and core needle biopsy. In a retrospective study reported by [22] of patients with tru-cut needle biopsies of breast lumps which was followed with excisional biopsy carried out in the Department of Surgery, University College Hospital, Ibadan over a ten-year period, Tru-cut needle biopsies had a comparable sensitivity and specificity to excisional biopsies. This made the Tru-cut the choice method for biopsy in the study population

Conclusion

The findings from this study has underscored the significant prevalence of breast cancer disease in the Federal Medical Centre, Abuja, Nigeria. The study highlighted critical patterns and characteristics associated with the disease in the region. The high incidence of grade II breast cancer among patients aligns with

previous reports, indicating its slower progression compared to other grades. Furthermore, invasive ductal carcinoma was found to be the most prevalent histological subtype, confirming its global dominance and relevance in breast cancer cases. While the study observed a slightly higher occurrence of cancer in the right breast, this result contrasts with some earlier reports that favor the left breast, suggesting possible regional or lifestyle-related factors at play.

The study also illustrated the predominance of Tru-cut biopsy as the diagnostic technique of choice, emphasizing its efficiency in detecting breast cancer in the population. The results from this study contribute to a deeper understanding of breast cancer dynamics in Nigeria, pointing to the importance of early detection and intervention strategies. Addressing challenges related to late-stage diagnosis, limited access to treatment, and lack of awareness can significantly improve survival outcomes. Therefore, the findings of this study serve as a guide to health practitioners and educators in the design and execution of campaign towards oncological studies in the Federal Medical Centre, Abuja.as well as advocate for greater public health initiatives, including education on early detection and better healthcare infrastructure, to combat the rising burden of breast cancer in Nigeria.

Conflict of Interest

There is no conflict of interest

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Effectiveness of Isoniazid Preventive Therapy among Patients on ART in Federal Medical Centre – Keffi, Nasarawa State, Nigeria: A Retrospective Cohort Study

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Abstract

A 6-month isoniazid as tuberculosis preventive therapy (TPT) for people living with HIV (PLHIV) was nationally introduced in Nigeria in 2014. However there has been limited research on the effectives of IPT specific to facilities like FMC – Keffi. This study is, therefore, conducted to evaluate the impact of IPT on the reduction of TB incidence in patients on ART in FMC-Keffi. A retrospective cohort study was conducted on HIV patients who commenced ART from October 2014 to September 2021. A data extraction script was used to extract data from the patient charts on the Electronic Medical Record (EMR). The effectives of IPT on TB incidence was assessed using the total person years, incidence rate ratio, and a multivariate regression model at 5% significance level. A sample size of 581, which included 444 exposed to TPT and 137 unexposed to TPT among PLHIV on ART records. We followed them up for a total of 2,361.66 -person-years of observation. The adjusted odds ratio (AOR) was 0.03 (95% CI: 0.00–0.26, p = 0.006). The results indicated that PLHIV on ART who received and completed a 6-month course of IPT (Exposed group) significantly reduced TB incidence by up to 97% in odds ratio (AOR) compared to does who didn't receive IPT. This study provides strong evidence that TPT significantly reduces the risk of TB in people living with HIV who are on ART. The findings emphasize the need to scale up TPT coverage, particularly for high-risk groups.

Keywords: *ART, IPT, PLHIV, Tuberculosis.*

Introduction

Tuberculosis (TB) is one of the main opportunistic infections in people living with HIV(PLHIV) and reports show that the risk of developing TB in PLHIV is 20–37 times higher than in those without HIV [1]. It was reported that PLHIV also have a significantly increased risk of developing extrapulmonary TB (40–80%) compared to those without HIV (10–20%) [2]. Furthermore, TB-related mortality accounts for 26% of the globally reported HIV deaths [3]. It was estimated that about one-fourth of the world's population is latently infected with mycobacterium tuberculosis [4]. In PLHIV, the lifetime risk of progression from latent TB infection to active disease is about 30% compared to the 10% risk in the general population [5]. According to the WHO global tuberculosis (TB) report, Africa had an estimated 212 total tuberculosis incidences and 42 HIV-positive tuberculosis incidence rates per 100,000 populations in 2021 [6]. Nigeria ranks 6th among the WHO TB high-burden countries and contributes 4% to the global TB burden. In 2021, it was ranked among the ten high-burden countries with low levels of treatment coverage and contributed to the number of multi-drug-resistant and rifampicin resistant TB globally [6]. The highest

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coinfection prevalence of 34.3% was recorded among the North Central States of Nigeria [7]. Nasarawa State is in North Central Nigeria and Federal Medical Center-Keffi Contribute to the diagnosis of approximately 43% of all reported TB cases in the state.

IPT involves the use of isoniazid, an anti-TB medication, to prevent the progression of latent TB infection to active disease. WHO guidelines strongly recommend IPT for PLHIV, regardless of CD4 count, as part of a comprehensive TB prevention strategy. The synergistic effects of IPT and ART have been shown to significantly reduce TB incidence among PLHIV, enhancing their overall health outcomes [26]. The World Health Organization (WHO) and the Nigerian national HIV guidelines recommends the use of a 6–36-month course with isoniazid (INH) as tuberculosis preventive treatment (TPT) to reduce the incidence of active TB in PLHIV [8, 9]. Several studies of different designs, including a meta-analysis, conducted between 2014 and 2020, confirmed the considerable protective effect of isoniazid preventive therapy (IPT) in PLHIV compared to those unexposed [10, 11]. This practice has not been generally accepted in the treatment of HIV patients as some physicians doubt its efficacy and fear the possibility of the development of resistance to INH [12]. Resistance to isoniazid in incident cases of TB has been reported in Africa and globally [13]. Development of resistance could worsen TB treatment outcomes [14]. Conclusions on the impact of IPT on all-cause mortality have, however, been conflicting [10, 11, 15]. In Nigeria, where both TB and HIV are endemic, IPT has been identified as a cost-effective intervention for TB prevention. Several studies have evaluated its impact. Lagos State: A retrospective study reported a significant reduction in TB incidence among PLHIV who completed a six-month IPT course [27]. Northern Nigeria: An observational study showed a 67% reduction in TB incidence among ART patients who received IPT [28]. A report from NTBLCP in 2020 emphasized the role of IPT in achieving Nigeria's TB elimination targets, despite challenges such as poor adherence and low coverage [29].

ART has been shown to independently reduce TB risk by restoring immune function in PLHIV. When combined with IPT, the reduction in TB incidence is more pronounced. Isoniazid preventive therapy (IPT) combined with antiretroviral therapy (ART) reduced the risk of developing active tuberculosis (TB) in people with HIV by almost 90% compared with no treatment in a South African study [30]. Despite its proven effectiveness, IPT implementation in Nigeria faces several challenges such as adherence (non-completion of the six-month IPT course remains a significant barrier) [31], Health System constraints: Inadequate supply chains and lack of trained healthcare workers limit IPT uptake (31), stigma and Awareness (Fear of stigma and low awareness among patients contribute to poor adherence to IPT protocols).

However, in 2014, a 6-month INH as TPT for PLHIV was programmatically introduced in Nigeria [16]. Following its launch and widespread implementation, the intervention was taken up by PLHIV in a number of Nigerian tertiary institutions, including the Federal Medical Center in Keffi, Nasarawa State. While evidence from other regions in Nigeria is promising, adverse reactions linked to INH and other unidentified factors have been reported in certain cases and, there is limited research specific to facilities like FMC – Keffi. Localized studies are crucial to understand contextual factors influencing IPT effectiveness, such as healthcare infrastructure, patient demographics, and adherence patterns. As a result, the effectiveness of INH in preventing TB has been an issue for physicians and PLHIV. This study is, therefore, conducted to evaluate the impact of IPT on the reduction of TB incidence in patients on ART in the Federal Medical Centre-Keffi, Nasarawa State, Nigeria

Materials and Methods

Study Area: This study will be conducted at Federal Medical Centre – Keffi, Nasarawa state located in north-central Nigeria. The facility contributes to the diagnosis of approximately 43% of all reported TB cases in the state. Federal Medical Centre - Keffi is a tertiary level hospital that provides comprehensive HIV/AIDS care including HIV testing and counselling (HTC), Adult and Pediatrics ART and prevention of mother-to-child transmission of HIV (PMTCT). The HIV/TB services in the hospital are fully integrated – patients who are receiving TB care are routinely screened for HIV, and those receiving HIV care are screened routinely for TB before commencing HIV antiretroviral treatment. The hospital provides free sputum acid fast bacilli (AFB) testing, Gene Xpert testing, and free tuberculosis and HIV treatment in accordance with the national treatment guidelines [17].

Study Design: Retrospective study using secondary data from the facility Electronic medical record, Nigeria medical record system (NMRS).

Study Population: The study population consisted of HIV-positive patients who were taking ART. The records were extracted from patients who started ART at the Federal Medical Centre in Keffi, Nasarawa State, between October 2014 and September 2021. Figure 1 shows the process of the inclusion and exclusion criteria to determine the cohort of patients selected for the study.

Inclusion Criteria: All HIV positive patients on ART, determined not to have active TB disease at time of ART commencement will be included.

Exclusion Criteria: All patients who had been diagnosed with TB or treated for TB before ART commencement, and those with unknown TB status at commencement will be excluded from the study. Also, patients without records of follow-up visits after the beginning of ART, and those who were transferred in with incomplete records will be excluded.

Exposure and Outcome Measurement: The main exposure of interest was confirmed completion of a 6-month course of daily INH 300 mg tablet for adults and 10 mg/kg for children as TB preventive therapy. Based on clinical records, PLHIV who had completed the 6-month course of IPT during the study period were considered as exposed and those who never took IPT were categorized as non-exposed. Both the exposed and unexposed groups were on ART. The primary endpoints were incident TB, diagnosed according to the national guideline at any time during the study period and the duration of protection of TB by IPT [9].

Sample Method: A design effect (DEFF) with estimated TB incidence among ART cases at 40%, and absolute precision of 2% will be used to determine the sample size. A systematic random sampling will be used to select the records to include in the study.

Sample Size: A sample size of 581 PLHIV on ART will be enough to evaluate the TB incidence and duration of protection of TPT among PLHIV exposed and unexposed to TPT in Federal Medical Centre – Keffi, with 40% relative precision.

Study Tools Various Schedules, Checklists: A structured data extraction script prepared for this purpose was used to collect historical data of patients from the EMR of the HIV care clinic. The data collection tool comprises the study participants' sociodemographic characteristics, treatment or exposure details, and treatment outcomes available on the NMRS. In instances where records are missing or incomplete, the data collectors update the records using the patient charts or folders.

Pretesting: Two data collectors were hired, and a one-day orientation workshop was held to familiarize them with the study's objectives, data collection methodology, and data collection tools. The data collectors' role is to update the EMR with information from patient charts or folders that are not fully captured on

the NMRS. Prior to data collection, the data extraction sheet was distributed to five experts in clinical pharmacy, medicine, health records (M&E), and epidemiology to ensure content validity. A three-day pre-test was conducted to collect historical data, and the results were used to improve the comprehensiveness of the data collected on the NMRS and ensure consistency of the data abstraction process and data collection approach. Before beginning the enrollment process, the data collectors screened all PLHIV clinical cards for eligibility, and cases that did not meet the eligibility criteria were immediately excluded from the study.

Data Collection: Retrospective data collected from the ART register, patient case notes and TB register at the facility would be entered into the EMR and the patient level data will remain on the local server at the facility.

Utilizing the data extraction scripts, information was obtained from the patient charts or folders. Sociodemographic information (sex, age, education level, employment status, marital status, and place of residence) as well as clinical information (date of HIV confirmation, date of ART initiation, WHO clinical stage, initial weight and height, TB status at enrolment, baseline CD4 count, previous ART, ART adherence) were all retrieved from the data. Additionally, I was able to obtain data regarding the start date of INH, the date INH was finished, compliance with INH, and the type of ART regimen (first line or second line) at the end of the study or the point of censorship. Additionally obtained were details regarding the patient's exposure status, outcome status, person-time contributed to follow-up, and whether the patient experienced ART treatment failure at any point during the follow-up period. The person-time of observation that each participant contributed to the study was computed and expressed in months. The number of months of observation from the conclusion of the 6-month IPT to the end of the study, or until the participant left the study for any reason, or until they developed the outcome of interest (TB), whichever came first, was the person-time contributed for the exposed participant. In contrast, the person-time contributed for the unexposed participant was calculated in terms of months from the start of ART to the completion of the study, or until the participant left the study or contracted tuberculosis. For both IPT and non-IPT, the personal time that each participant contributed was calculated and added up.

Statistical Analysis: Data was extracted from the facility EMR database using a structured query language (SQL) script and exported into Microsoft Excel and analyzed using R 4.0.4 [18]. The Data cleaning, transposing, mapping, classification and analysis was carried out using R 4.0.4. Descriptive statistics including percentages, frequencies, number needed to treat, mean (SD), and median (IQR) were computed as appropriate. Participants with missing data in specific variables of interest were not included in the analysis of a specific variable. The incidence rate of TB was computed using descriptive statistics and, as the cohort was dynamic, the incidence rate of active TB in exposed and unexposed with person-time (years) in the denominator was used as a measure of frequency. Chi-square test of independence and multivariate logistic regression were used to identify factors that are associated with incident TB. Rate ratio or hazard ratio with 95% confidence interval was used as a measure of association or impact of IPT on the prevention of TB. For all statistical tests, a two-sided alpha level of 0.05 was used to determine statistical significance.

Ethical Considerations: The Research and Ethics Committee of FMC-Keffi, Nasarawa State, granted me ethical approval (FMC/KF/HREC/027101/24). The computer containing the data was password-protected. Given that the study was retrospective in nature, informed consent from the patients was not required.

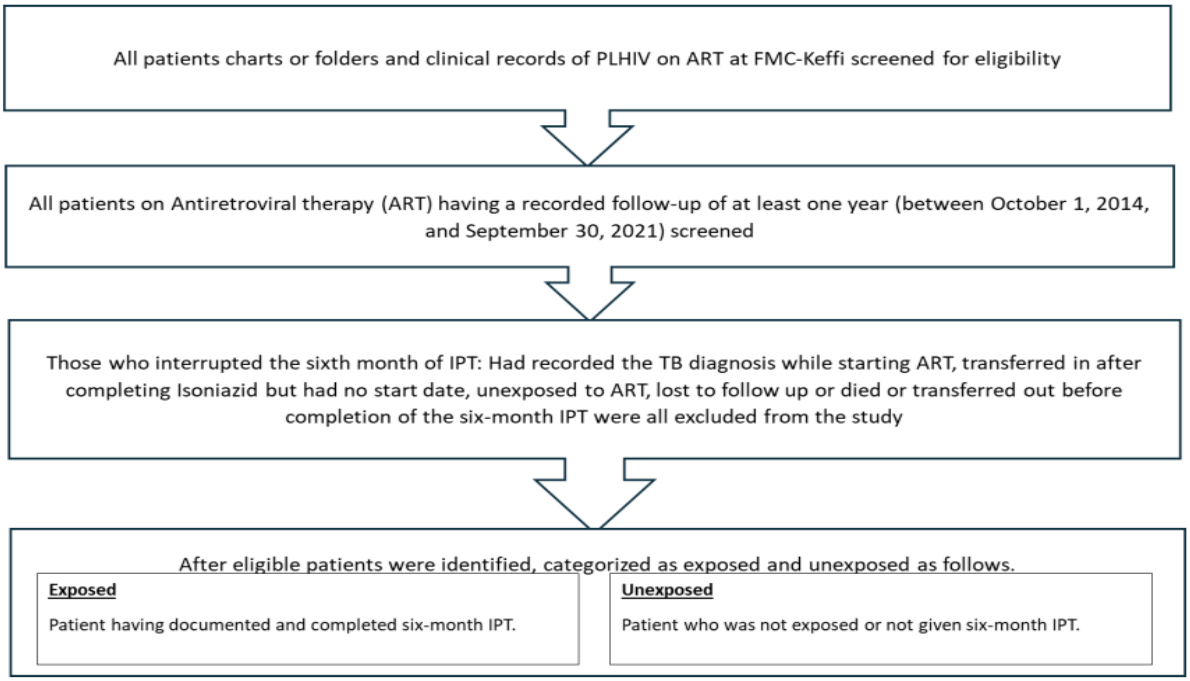

Figure 1. Study Participant Selection Process

a. *Study participants selection process on effectiveness of isoniazid preventive therapy (IPT) among patients on ART in FMC-Keffi, Nasarawa State*.

Results

The socio-demographic and clinical characteristics of respondents in this study revealed significant insights into the dynamics of tuberculosis (TB) prevention and disease outcomes among individuals exposed to tuberculosis preventive therapy (TPT) compared to those who were not. Additionally, the data allowed for an in-depth understanding of how these characteristics related to the development of TB.

TPT Exposure and Associated Characteristics

The socio-demographic and clinical profiles of 581 respondents, stratified by their receipt of tuberculosis preventive therapy (TPT). Of the respondents, 137 did not receive TPT, while 444 were on TPT. Key characteristics are discussed below and shown in Table 1.

Sex Distribution: Both groups had a majority of female participants. Among those exposed to TPT, 70% were female, a proportion similar to the unexposed group (69%). This consistency indicates no gender-based disparity in TPT exposure.

Age Patterns: The median age was slightly higher in the TPT-exposed group (39 years, IQR: 32–46) compared to the unexposed group (37 years, IQR: 26–45). Interestingly, younger individuals (<15 years) were more common in the unexposed group (15%) than in the exposed group (6.5%), while the reverse was true for those aged 26–55 years (81% in the exposed group vs. 69% in the unexposed group). This age distribution suggests that younger individuals may have been less prioritized for TPT, possibly due to perceived lower risks or challenges in access.

Weight Differences: The median weight at baseline was higher in the exposed group (61 kg, IQR: 49–70) compared to the unexposed group (55 kg, IQR: 30–67). This observation may reflect better overall health or different clinical prioritization criteria for TPT initiation.

WHO HIV Staging: Most participants in both groups were classified as WHO HIV Stage 1, with a slightly higher proportion in the

exposed group (62%) than in the unexposed group (59%).

HIV Viral Load: The median HIV viral load for the overall cohort was 20 copies/mL with an interquartile range (IQR) of 20 to 130 copies/mL. Among those exposed to tuberculosis preventive therapy (TPT), the median viral load was 20 copies/mL (IQR: 20 to 81 copies/mL), indicating better viral suppression compared to the unexposed group, which had a higher median viral load of 23 copies/mL (IQR: 20 to 3,940 copies/mL). The proportion of missing values for HIV viral load was substantial, with 222 observations missing overall, distributed as 162 in the exposed group and 60 in the unexposed group.

CD4 Count: The overall median CD4 count was 288 cells/µL (IQR: 171 to 522 cells/µL). Participants exposed to TPT had a slightly higher median CD4 count of 306 cells/µL (IQR: 176 to 519 cells/µL) compared to their unexposed counterparts, who's median CD4 count was 265 cells/µL (IQR: 170 to 549 cells/µL), suggesting that individuals with better immunological profiles were more likely to be initiated on TPT. Missing data for CD4 count was also notable, with 420 observations missing overall, distributed as 328 in the exposed group and 92 in the unexposed group.

CD4 Count Category: The CD4 count category distribution revealed that: 29% of the overall cohort had a CD4 count less than 200 cells/µL, with similar proportions in the exposed (28%) and unexposed (31%) groups. 29% had a CD4 count between 200 and 350 cells/µL, evenly distributed across both the exposed (28%) and unexposed (31%) groups. 42% had a CD4 count greater than 350 cells/µL, with a slightly higher proportion in the exposed group (44%) compared to the unexposed group (38%). There were 420 missing observations for the CD4 count category, with 328 in the exposed group and 92 in the unexposed group.

ARV Regimen: The majority of participants in both groups were on the adult first-line ARV regimen, with a higher prevalence in the TPT-exposed group (90%) compared to the unexposed group (76%).

Table 1. Socio-Demographic and Clinical Characteristics of Respondents by Treatment Group

		Tuberculosis Preventive Therapy	
Variable	**Overall**, N = 581[1]	**Exposed**, N = 444[1]	**Unexposed**, N = 137[1]
Sex			
Female	404 (70%)	309 (70%)	95 (69%)
Male	177 (30%)	135 (30%)	42 (31%)
Age Years			
Median (IQR)	39 (32, 45)	39 (32, 46)	37 (26, 45)
Age Category			
<15 years	49 (8.4%)	29 (6.5%)	20 (15%)
16 - 25 years	33 (5.7%)	21 (4.7%)	12 (8.8%)
26 - 55 years	456 (78%)	361 (81%)	95 (69%)
>55 years	43 (7.4%)	33 (7.4%)	10 (7.3%)
Weight (Kg)			
Median (IQR)	59 (45, 69)	61 (49, 70)	55 (30, 67)
(Missing)	231	170	61
Pregnancy Breastfeeding Status			
Breastfeeding	11 (2.8%)	10 (3.3%)	1 (1.2%)
Not Pregnant	369 (94%)	290 (94%)	79 (94%)
Pregnant	11 (2.8%)	7 (2.3%)	4 (4.8%)

(Missing)	190	137	53
WHO_HIV Stage			
1	356 (61%)	275 (62%)	81 (59%)
2	129 (22%)	99 (22%)	30 (22%)
3	87 (15%)	62 (14%)	25 (18%)
4	9 (1.5%)	8 (1.8%)	1 (0.7%)
HIV Viral Load			
Median (IQR)	20 (20, 130)	20 (20, 81)	23 (20, 3,940)
(Missing)	222	162	60
CD4_count			
Median (IQR)	288 (171, 522)	306 (176, 519)	265 (170, 549)
(Missing)	420	328	92
CD4_count_category			
Less than 200	46 (29%)	32 (28%)	14 (31%)
200 – 350	47 (29%)	33 (28%)	14 (31%)
Greater than 350	68 (42%)	51 (44%)	17 (38%)
(Missing)	420	328	92
Regimen Line at Start of ART			
Child 1st line ARV regimen	74 (13%)	43 (9.8%)	31 (24%)
Child 2nd line ARV regimen	1 (0.2%)	1 (0.2%)	0 (0%)
Adult 1st line ARV regimen	495 (87%)	396 (90%)	99 (76%)
Adult 2nd line ARV regimen	1 (0.2%)	0 (0%)	1 (0.8%)
(Missing)	10	4	6
[1]n (%)			

b. *TPT Exposure and associated characteristics among 581 patients*

Characteristics by Tuberculosis Status

Among the 581 respondents, 27 developed TB during the study period, while 554 did not. Examining these groups revealed critical differences seen below and shown in Table 2.

Sex: Females were more likely to develop TB, comprising 74% of TB cases, compared to 69% among those who remained TB-free.

Age: The median age was comparable between the TB and non-TB groups (40 years vs. 39 years). However, age distribution showed slight variations, with TB more frequent in individuals aged 26–55 years (81%) compared to other age groups.

Weight: Participants who developed TB had a lower median weight (55 kg, IQR: 45–67) than those who did not (59 kg, IQR: 45–70), potentially reflecting poorer nutritional or overall health status among TB cases.

HIV Characteristics

Participants in advanced HIV stages (Stages 3 and 4) were more likely to develop TB (33% of TB cases) compared to those in Stages 1 and 2 (15% of TB cases). Median CD4 counts were lower in TB cases (237, IQR: 145–605) than in non-TB cases (289, IQR: 175–519), reaffirming the role of immune suppression in TB progression.

Table 2. Socio-Demographic and Clinical Characteristics of Respondents by Tuberculosis Status

			Tuberculosis Status		
Variable	**N**	**Overall**, N = 581[1]	**Developed tuberculosis**, N = 27[1]	**Did not develop tuberculosis**, N = 554[1]	**p-value**[2]
Sex	581				0.6
Female		404 (70%)	20 (74%)	384 (69%)	
Male		177 (30%)	7 (26%)	170 (31%)	
Age Years	581				0.8
Median (IQR)		39 (32, 45)	40 (29, 45)	39 (32, 45)	
Age Category	581				0.9
<15 years		49 (8.4%)	2 (7.4%)	47 (8.5%)	
16 - 25 years		33 (5.7%)	2 (7.4%)	31 (5.6%)	
26 - 55 years		456 (78%)	22 (81%)	434 (78%)	
>55 years		43 (7.4%)	1 (3.7%)	42 (7.6%)	
Weight (Kg)	350				0.7
Median (IQR)		59 (45, 69)	55 (45, 67)	59 (45, 70)	
(Missing)		231	12	219	
Pregnancy Breastfeeding Status	391				>0.9
Breastfeeding		11 (2.8%)	0 (0%)	11 (3.0%)	
Not Pregnant		369 (94%)	19 (100%)	350 (94%)	
Pregnant		11 (2.8%)	0 (0%)	11 (3.0%)	
(Missing)		190	8	182	
WHO_HIV Stage	581				0.10
1		356 (61%)	13 (48%)	343 (62%)	
2		129 (22%)	5 (19%)	124 (22%)	
3		87 (15%)	8 (30%)	79 (14%)	
4		9 (1.5%)	1 (3.7%)	8 (1.4%)	
HIV Viral Load	359				0.3
Median (IQR)		20 (20, 130)	45 (20, 100)	20 (20, 131)	
(Missing)		222	12	210	
CD4_count	161				>0.9
Median (IQR)		288 (171, 522)	237 (145, 605)	289 (175, 519)	
(Missing)		420	20	400	
CD4_count_category	161				0.5
Less than 200		46 (29%)	3 (43%)	43 (28%)	
200 – 350		47 (29%)	1 (14%)	46 (30%)	
Greater than 350		68 (42%)	3 (43%)	65 (42%)	

(Missing)		420	20	400	
Regimen Line at Start of ART	571				0.8
Child 1st line ARV regimen		74 (13%)	4 (15%)	70 (13%)	
Child 2nd line ARV regimen		1 (0.2%)	0 (0%)	1 (0.2%)	
Adult 1st line ARV regimen		495 (87%)	23 (85%)	472 (87%)	
Adult 2nd line ARV regimen		1 (0.2%)	0 (0%)	1 (0.2%)	
(Missing)		10	0	10	
[1]n (%)					
[2]Pearson's Chi-squared test; Wilcoxon rank sum test; Fisher's exact test					

c. *Characteristics by Tuberculosis Status across the different variables*

Incidence Rate Analysis

The incidence rate of TB was significantly lower in the TPT-exposed group compared to the unexposed group; this is shown in Table 3.

TPT-Exposed Group: Among the 444 individuals who received TPT, there were 12 TB cases over 1,785.24 person-years, resulting in an incidence rate of 6.72 per 1,000 person-years.

TPT-Unexposed Group: In the 137 unexposed individuals, 15 TB cases occurred over 576.42 person-years, yielding a much higher incidence rate of 26.02 per 1,000 person-years.

Incident Rate Ratio: The incident rate ratio is approximately 0.26. The IRR of 0.26 indicates that the exposed group has a 74% lower incidence rate of developing TB as compared to the unexposed group.

Table 3. TB Incidence Rates According to TPT Status

TB Preventive Therapy	Number of persons	Number of tuberculosis cases	Total person years	Incidence rate (per 1000 person years)	Incident rate ratio
Exposed	444	12	1,785.24	6.72	1.00
Unexposed	137	15	576.42	26.02	3.87

d. *Incident rate analysis among the exposed and unexposed group*

Crude and Adjusted Odds Ratios

Multivariate regression analysis further highlighted the protective role of TPT as shown below in Table 4.

Sex: In the crude analysis, males had a higher odds ratio (OR = 1.26; 95% CI: 0.55–3.28; p = 0.6) for developing tuberculosis (TB) compared to females. This association, however, was not statistically significant. After adjusting for confounders, the odds for males further increased to 3.46 (95% CI: 0.36–90.8; p = 0.3), but the wide confidence interval indicates high variability in the estimate, and the result remained non-significant.

Age Categories: The association between age and incident TB was analyzed across four age categories, using those aged under 15 years as the reference group:

1. Ages 16–25 years: The crude analysis showed a lower odds ratio (OR = 0.66; 95% CI: 0.08–5.73; p = 0.7), suggesting a reduced risk

compared to the reference group, but this result was not statistically significant. The adjusted analysis produced an extremely high odds ratio (OR = 2,053,516,521), with an undefined upper confidence interval (NA) and a p-value > 0.9, reflecting instability in the model and no significant association.

2. Ages 26–55 years: The crude analysis showed an OR of 0.84 (95% CI: 0.13–2.97; p = 0.8), indicating no significant relationship with incident TB. After adjustment, the odds ratio increased to 7.48 (95% CI: 0.00–3,349; p = 0.6), but the result remained non-significant with high uncertainty.

3. Ages >55 years: The crude analysis suggested a potential increased risk (OR = 1.79; 95% CI: 0.17–39.3; p = 0.6), but this result was not significant. The adjusted analysis yielded an extremely high odds ratio (OR = 844,860,815), with undefined confidence intervals and a p-value > 0.9, indicating no meaningful association.

TPT Exposure: PLHIV on ART who received TPT had significantly lower odds of developing TB. The adjusted odds ratio (AOR) was 0.03 (95% CI: 0.00–0.26, p = 0.006), indicating a 97% reduction in odds of TB development compared to the unexposed group after adjusting for other factors. A statistically significant and strong protective relationship between PLHIV on ART who received TB preventive therapy, and their risk of contracting TB is indicated by the p-value (p = 0.006)

WHO HIV Stage: Advanced HIV stages (3 and 4) were associated with increased odds of developing TB in crude models. However, these associations lost statistical significance after adjustment, likely due to overlapping immunosuppressive effects captured by CD4 count variables.

CD4 Count: Lower CD4 counts were associated with a higher likelihood of TB in crude models, but these associations were not statistically significant in the adjusted models.

Table 4. Crude and Adjusted Odds Ratios using Multivariate Regression Model

	Crude Ors				**Adjusted ORs**		
Variable	**N**	**OR**[1]	**95% CI**[1]	**p-value**	**OR**[1]	**95% CI**[1]	**p-value**
Sex	581						
Female							
Male		1.26	0.55, 3.28	0.6	3.46	0.36, 90.8	0.3
Age Category	581						
<15 years							
16 - 25 years		0.66	0.08, 5.73	0.7	2,053,516,521	0.00, NA	>0.9
26 - 55 years		0.84	0.13, 2.97	0.8	7.48	0.00, 3,349	0.6
>55 years		1.79	0.17, 39.3	0.6	844,860,815	0.00, NA	>0.9
WHO_HIV Stage	581						
1							
2		0.94	0.35, 2.98	>0.9	0.00		>0.9
3		0.37	0.15, 0.97	0.035	0.00		>0.9
4		0.30	0.05, 5.84	0.3	0.00		>0.9
CD4_Count_ Category	161						

Less than 200							
200 – 350		3.21	0.39, 66.2	0.3	3.00	0.25, 77.4	0.4
Greater than 350		1.51	0.27, 8.50	0.6	0.30	0.02, 4.05	0.4
TB Preventive Therapy	581						
Unexposed							
Exposed		0.23	0.10, 0.49	<0.001	0.03	0.00, 0.26	0.006
[1]OR = Odds Ratio, CI = Confidence Interval							

e. *Crude and adjusted odds ratio to describe the strength and direction of the association between TPT and TB incidence after adjusting for potential confounders.*

Discussion

We set out to evaluate the effectiveness of IPT among PLHIV on ART reviewing the incidence of TB among PLHIV on ART who received IPT and those who had not received IPT among patient on ART from October 2014 to September 2021. The study found that ART patients who had received the 6-month course IPT and completed treatment (exposed group) had a reduced risk of developing TB. WHO HIV stage and CD4 count were associated with higher likelihood of developing TB but were not statistically significant. The incidence of TB among the participants who received IPT was low as seen from other studies [15, 19]. This could be due to the high level of implementation of IPT among PLHIV on ART in Nigeria [20]. The WHO's guidance and global reports on TB and HIV co-infection also backs the significant reduction of TB incidence when IPT is combined with ART for PLHIV. This approach is recommended as part of the comprehensive TB prevention strategy [21]. The protective effect of IPT is well-supported, with research showing that those who completed the 6-month regimen had a lower incidence of TB, and their CD4+ T cell count improved significantly as reported in a systematic review study in Ethiopia [22]. The six-month course of isoniazid independently lowers the incidence of TB by 97% among HIV patients on ART. The lowering of incidence of TB by INH in this study is comparable to findings in a meta-analysis highlights that IPT, particularly when combined with ART, significantly reduces TB incidence in PLHIV. This research supports the claim that IPT reduces TB risk by up to 76% [23]. The rate of developing tuberculosis among the exposed compared to the unexposed was significantly lower. Our study population were patients who were already on ART. Being on ART substantially reduce the risk of TB among HIV patients. The period of observation was much higher for those who had received INH prophylaxis compared to those who had not. However, the result also indicate that 6-month isoniazid confers additional protection against TB on PLHIV who had been on ART among those who received IPT.

PLHIV who were in an advanced stage of HIV and those who had low CD4 count to their antiretroviral treatment were at greatest risk of developing TB. The relationship between advanced HIV disease and the development of TB is probably due to severe immunosuppression associated with the advance HIV infection and CD4 count (low CD4 count). Tuberculosis infection is also one of the opportunistic infections observed at this stage of HIV infection. The relationship between TB, advanced HIV and low CD4 count to ART are in keeping with other studies [24]. Patients with advanced HIV disease and those with low CD4 count on ART should be identified early and ensure they are placed on

IPT to protect them from developing active TB. Interestingly, younger individuals (<15 years) were more common in the unexposed group (15%) than in the exposed group (6.5%), this age distribution suggests that pediatrics and adolescents may have been less prioritized for TPT, possibly due to perceived lower risks or challenges in access. The recommendation given in a study (Taking tuberculosis preventive therapy implementation to national scale: the Nigerian PEPFAR Program experience) stated that the provider-to-client stage of TPT implementation be driven by the HIV program and that cross-communication between the two programs (TB and HIV) be improved [25]. This will ensure the right IPT regimen is provided for pediatrics and adolescents looking at their corresponding weight since INH is mainly procured by the NTBLCP under the TB program.

The study had the following limitations: Among PLHIV on ART with at least a year of documented follow-up on either ART alone or ART and IPT, this observational study assessed the efficacy of a completed 6-month IPT (Exposed group). Therefore, the results of this study could not be applied to individuals who died or were lost to follow-up without at least a year of documented follow-up. The study cohort of patients who initiated or started ART from October 2014 to September 2021, the role out of IPT in Nigeria started in 2014, but adoption by health facility was delayed until 2016-2017, therefore leading to patients who had TB before the intervention (IPT), as such including these cohorts of patients to either group would give a false result, thereby reducing the transparency of the research study. Patients were considered unexposed if they had IPT for fewer than six months. The difference between the exposed and unexposed may have been influenced by the amount of isoniazid received, and depending on the TB diagnosis of others—some of whom may have had a clinical diagnosis—may have resulted in a different incidence than the gold standard of having a confirmatory TB diagnosis. I worked with the ART and TB Clinic to compare their data with my findings in order to reduce this.

Salient recommendations on the problems studied: We recommend that HIV program managers should optimize placing PLHIV with advanced HIV stages and those with lower CD4 count on IPT. The current guideline of test and treat should be strengthened to avoid deterioration of the patient WHO clinical stage. Those identified at an advanced stage of the disease should be specifically targeted for intervention to low their risk of developing TB.

Future efforts should address gaps in TPT access, particularly among younger populations and those with lower baseline weights, to ensure equitable protection against TB. These findings also underscore the importance of integrating weight and immunological status into clinical decision-making for TB prevention

Conclusion

The incidence rate of TB among HIV patients who had received IPT was 6.72 per 1000-person-year of observation, while that among HIV patients who had not received IPT the incidence was 26.02 per 1000-person-year of observation. This study provides strong evidence that TPT significantly reduces the risk of TB in individuals living with HIV. The findings emphasize the need to scale up TPT coverage, particularly for high-risk groups such as those with advanced HIV stages or lower CD4 counts.

Conflict of Interest

There is no conflict of Interest.

Acknowledgements

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Prevalence and Determinants of Non-Communicable Diseases Risk Factors Among In-School Adolescents in Rural and Urban Areas of Adamawa State

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Abstract

This study investigates the prevalence and determinants of non-communicable disease (NCD) risk factors among in-school adolescents in Adamawa State, Nigeria. A total of 624 adolescents participated, with 308 from rural schools and 316 from urban schools. The mean age was significantly higher in urban areas (15.79 ± 2.0 years) compared to rural areas (14.94 ± 1.9 years; p<0.001). Notable differences in ethnic and religious distributions were observed, with a higher proportion of Christians in rural areas (59.4%) and Muslims in urban areas (63.9%; p<0.001). Alcohol consumption was reported by 32.5% of urban respondents and 26.4% of rural respondents, though not statistically significant (p=0.0846). Smoking rates were slightly higher in urban areas (4.7%) compared to rural (3.2%, p=0.066). Dietary assessments showed inadequate fruit and vegetable intake in both settings, while physical activity levels were significantly different, with more rural adolescents (31.1%) reporting low activity compared to urban peers (17.1%, p<0.001). The prevalence of obesity was higher in urban adolescents (4.5% vs. 1.7%; p=0.049). These findings underscore the need for targeted interventions to mitigate NCD risk factors among adolescents.

Keywords: *Adolescents, In-school, Non-Communicable Diseases Risk factors, Rural Area, Urban Area.*

Introduction

Non-communicable diseases (NCDs) are increasingly recognized as a significant public health challenge, especially among adolescents in Nigeria. The growing prevalence of NCD risk factors, such as unhealthy dietary habits, physical inactivity, and substance use, poses serious threats to the health of young people [19].

Understanding the prevalence and determinants of NCD risk factors among adolescents is critical for developing effective health interventions. Despite the urgency, existing literature often focuses on adult populations or lacks comprehensive data on youth-specific risk factors, limiting the effectiveness of public health initiatives [1].

NCDs and the associated risk factors have emerged rapidly, becoming a major Public Health challenge worldwide [9]. NCDs now account for 48% of the world Disability Adjusted Life Years (DALYs) compared with 40% for communicable diseases, maternal and perinatal conditions, nutritional problems, and 1% for injuries [7].

In the past decade, cardiovascular diseases have become the single largest cause of death worldwide, representing nearly 30% of all deaths and about 50% of NCD deaths ([12]. The estimated global burden of diabetes in 2019 was 463 million, up from 382 million in 2013, and projected to reach 700 million by 2045 [11] with an estimated 4.8 million deaths from diabetes and its complications annually. In Nigeria about 3.2 million people have diabetes

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and 2.5 million of them are unaware of this [11].

The global prevalence of hypertension is 40% and this is annually estimated to cause 9.4 million deaths globally, many of these being preventable deaths [18]. The prevalence of raised blood pressure is highest in the African region (46%) and among the Low and Middle-Income Countries (LMICs) [18]. The burden of chronic respiratory diseases is also alarmingly high.

Four behavioral risk factors are responsible for most NCDs. About 80% of deaths due to cardiovascular disease, stroke, and type 2 diabetes and 40% of deaths due to cancers could be prevented by eliminating these known risk factors [18]. Physical inactivity is associated with a 20-30% increase in the risk of mortality from various causes with approximately 1.6 million deaths annually associated with conditions resulting from or complicated by physical inactivity. Efforts focused on a better diet and increased physical activities have been shown to control the prevalence of NCD [16].

Adolescents are important groups that are overlooked in the fight against NCDs, yet they are a natural partner for preventing NCDs. The WHO estimates that 70% of premature deaths in adults are the result of behaviors begun during adolescence and youth [17]. Furthermore, children's bodies are especially vulnerable to the same risk factors responsible for many NCDs in adulthood (low physical activity, poor diet, and tobacco exposure, harmful use of alcohol), and the rates of some NCDs amongst children are already on the rise globally (e.g. obesity and Type 2 Diabetes), so reducing exposure to these risk factors earlier in life will have a substantial impact on the future health of entire populations group [14].

A study among 1638 adolescents in an urban community in Nigeria found the prevalence of overweight was high in both genders (0-8.1% and 1.3-8.1% in males and females respectively) [3]. Another study in 2011 among young people in Ibadan showed that 1.9% of the respondents smoked an average of four sticks of cigarette/day, 8.5% of them engaged in harmful use of alcoholic drinks. The commonest type of diet was starchy foods with about 28.1% and 33.5% taking fast foods and sugared beverages respectively and 2.3% taking fruits as part of their regular diet [5].

The understanding of the magnitude of risk factors gathering and analysis of available data among adolescents is important because this can provide insight into the likely future burden of NCDs. Documenting youth risk behaviors can also help to focus policies and programs designed to mitigate risks and promote healthy lifestyles. Risks may differ by gender, ethnicity, rural versus urban residence, or other social and environmental factors. It is important to understand and document these differences so that interventions can be well-tailored to various subgroups, ensuring that resources are spent in the most effective and efficient ways possible.

Any strategy that adopts a life course approach to NCD prevention will offer the best chance of overcoming key NCD risk factors and would give everybody the right of all to a healthy life. A predominant focus on adults will systematically neglect important opportunities to reduce NCD risk factors from the earliest possible stages. By contrast, a focus on children promotes generational and population-based change and empowers a pro-active approach to the primary, secondary and tertiary prevention of NCDs.

This study focuses on assessing the prevalence and determinants of NCD risk factors among adolescents in urban and rural areas. Understanding the differences between these settings is crucial for developing effective public health strategies aimed at reducing the burden of NCDs.

Previous studies have inadequately addressed the socio-economic factors influencing health behaviors, which may lead to poorly targeted health interventions [10]. This

study aims to fill this gap by providing a comparative analysis of urban and rural adolescents in Adamawa State.

Health education programs targeting dietary habits and physical activity have shown some effectiveness in reducing NCD risk factors among youth [8]. However, many interventions lack cultural relevance and fail to consider local socio-economic contexts.

This research presents a novel perspective by examining the interplay of socio-demographic factors and NCD risk behaviors among adolescents in both rural and urban settings, offering empirical data for tailored public health policies.

Materials and Methods

A cross-sectional survey was conducted involving 624 adolescents aged 12-18 years from selected urban (n=316) and rural (n=308) schools in Adamawa State. Participants were recruited using stratified random sampling to ensure representation across various socio-demographic backgrounds. Data collection involved structured questionnaires covering socio-demographic characteristics, parental education, and health behaviors, including alcohol and tobacco use, dietary habits, and physical activity levels. Statistical analysis was performed using SPSS version 26, with significance set at $p<0.05$.

Adamawa State is located in the North East geo-political zone of Nigeria. It was created in 1991 from the northeastern half of the former Gongola state. Adamawa state is bordered on the north and northwest by Borno and Gombe states, on the west and southwest by Taraba state, and on the southeast and east by the Republic of Cameroon.

Adamawa state is largely covered by short-grass savanna and is drained westward by the Benue River and its tributaries, including the Gongola, Taraba, and Pai rivers. The state occupies about 38,000 square kilometers. The population of Adamawa was four million eight hundred and sixty-four thousand four hundred and four projected from the 2006 census [20]. The state capital is Yola and there are 21 LGAs in the state. The main languages are Hausa, and Fulfulde and there are over 78 tribes/ethnic groups in the state.

This study will be carried out in two LGAs in the state one rural and the other urban that have a reasonable distance apart.

Research design

This is a comparative cross-sectional study designed to determine the prevalence and determinants of risk factors for non-communicable diseases among adolescents in rural and urban public secondary schools of Adamawa state.

Study Population

The study populations would be female and male adolescent students (aged 10 years to 19 years) from Junior Secondary Schools (JSS) 1 to JSS 3 and Senior Secondary Schools (SSS) 1 to SSS 3 in secondary schools in one rural and one urban area in Adamawa State.

Sampling Technique

The participants were selected using a multi-stage sampling technique for both the rural and urban groups.

Stage one: Selection of LGAs

Adamawa State was stratified into urban and rural LGA. One urban and one rural LGA would be selected by simple random sampling by balloting.

Stage two: Selection of secondary schools from LGAs.

A list of all the registered secondary schools in the selected LGAs were obtained from the Adamawa State Ministry of Education. All public schools in Adamawa State are classified into junior and senior secondary schools. To cover the adolescent aged group (10-19 years), one senior secondary school and one junior secondary school were selected from the list of schools from each of the selected LGA by simple random sampling by balloting.

Stage three: The cluster sampling technique was used in this stage.

The Secondary schools in the two LGAs were stratified by grades /classes into JSS1 to JSS3 for the junior public secondary schools and SS1 to SS3 for the senior public secondary schools. Classes in the schools have arms. Based on the stratified class arrangements, one arm per grade would be selected by simple random sampling by balloting. All students who met the inclusion criteria in the selected classes were included in the study.

Data Collection/Analysis Technique

Data collection was carried out in a facilitated structured self-administered questionnaire adapted from the Global School-Based Student Health Survey (GSHS) questionnaire [21]. WHO STEPS chronic disease risk factor surveillance instrument and a modified version of the International Physical Activity Questionnaire (IPAQ-A) for adolescents [22], [23].

The filled questionnaires were thoroughly checked by the principal researcher for any inconsistencies. Data coding and cleaning were done. Completed questionnaires and physical measurements would be entered into IBM Statistical Package for Social Science Statistics version 20.0.

Results

The mean age of respondents was significantly higher in urban (15.79 ± 2.0 years) compared to rural areas (14.94 ± 1.9 years; $p<0.001$). Ethnic distribution revealed that the "Other" tribe was predominant, especially in rural schools (64.9% vs. 45.9% in urban schools; $p<0.001$) [Table 1].

Educational attainment of parents varied significantly, with a higher proportion of urban mothers holding postgraduate degrees (11.1%) compared to rural mothers (9.7%, $p<0.001$) [Table 2]. Alcohol consumption was reported by 32.5% of urban adolescents compared to 26.4% in rural areas, although the difference was not statistically significant ($p=0.0846$) [Table 3].

Smoking prevalence was slightly higher in urban areas (4.7%) than in rural (3.2%), with no statistically significant difference ($p=0.066$) [Table 4]. Dietary assessments indicated that 87.9% of rural and 83.2% of urban respondents did not meet recommended fruit and vegetable intake [Table 5].

Physical activity levels were significantly different, with more rural adolescents reporting low physical activity (31.1%) compared to urban adolescents (17.1%; $p<0.001$) [Table 6]. Obesity prevalence was higher in urban adolescents (4.5% vs. 1.7%; $p=0.049$) [Table 6]. Mean systolic blood pressure was significantly higher in urban adolescents (105 ± 12.2 mmHg) compared to rural (103.3 ± 11.7 mmHg; $p<0.006$) [Table 7].

Discussion

The findings of this study reveal significant differences in the prevalence and determinants of NCD risk factors among adolescents in Adamawa State. The observed differences in mean age between urban and rural respondents may indicate the influence of rural-urban migration, which affects access to health resources and education [15].

The higher prevalence of alcohol consumption among urban adolescents may reflect increased exposure to urban lifestyles and peer pressures that promote substance use [6]. Despite the slightly higher rates of smoking in urban areas, overall prevalence remained low, suggesting the effectiveness of ongoing anti-tobacco initiatives and the need for sustained efforts to curb emerging tobacco use trends.

Dietary habits revealed concerning trends, with the majority of adolescents failing to meet recommended fruit and vegetable intake, a critical factor in preventing NCDs [2]. This necessitates the development of culturally sensitive nutritional education programs that promote healthier dietary choices among

adolescents, particularly in urban environments where convenience foods are prevalent.

Physical activity levels indicate a significant disparity, with a greater percentage of rural adolescents reporting low physical activity compared to urban counterparts [1]. This discrepancy emphasizes the need for community-based physical activity programs aimed at increasing engagement among rural youth.

The higher prevalence of obesity and elevated systolic blood pressure in urban adolescents reflects global patterns of urbanization contributing to lifestyle-related health issues [4]. This indicates an urgent need for targeted interventions focused on promoting healthy lifestyle choices among urban youth.

In conclusion, the findings of this study emphasize the pressing need for targeted interventions addressing NCD risk factors among adolescents in Adamawa State. Public health strategies should be tailored to the specific needs of urban and rural adolescents, focusing on enhancing nutritional knowledge, promoting physical activity, and addressing substance use. Future research should further explore these dynamics to inform policy and practice.

Conclusion

This study reveals significant disparities in the prevalence and determinants of NCD risk factors among in-school adolescents in Adamawa State. The findings highlight the need for targeted health interventions tailored to the specific contexts of urban and rural populations, aiming to mitigate the rising risk of NCDs among adolescents.

Table 1. Socio-Demographic Characteristics of Respondents

Socio-demographic characteristics	Rural	Urban	t-test/ $\chi 2$	p-value
	N =308 n (%)	N=316 n (%)		
Age (years)			16.5	<0.0001
10 – 13 (early adolescence)	74 (24)	49 (15.5)	t = -4.833	p= 0.000
14 – 16 (mid-adolescence)	165 (53.6)	153 (48.4)		
17 – 19 (late adolescence)	69 (22.4)	114 (36.1)		
Mean + SD	14.94 (1.948)	15.7 (2.017)		
Gender			0.573	0.449
Male	132 (42.9)	126 (39.9)		
Female	176 (57.1)	190 (60.1)		
Ethnicity			23.32	<0.0001
Yoruba	4 (1.3)	4 (1.3)		
Igbo	14 (4.5)	22 (7.0)		
Hausa	90 (29.2)	145 (45.9)		
Others	200 (64.9)	145 (45.9)		
Religion			59.313	<0.0001
Christianity	183 (59.4)	93 (29.4)		
Islam	109 (35.4)	202 (63.9)		
Traditional	12 (3.9)	19 (6.0)		
Others	4 (1.3)	2 (0.6)		
Class			1.4984	0.9132
JSS1	53 (17.2)	50 (15.8)		
JSS2	61 (19.8)	56 (17.7)		
JSS3	49 (15.9)	50 (15.8)		

SS1	53 (17.2)	52 (16.5)		
SS2	58 (18.8)	68 (21.5)		
SS3	34 (11.0)	40 (12.7)		

*Statistically significant at p<0.05

Table 2. Comparison of Respondents' Parents' Socio- Economic Characteristics

Socio-economic characteristics	Rural	Urban	$\chi 2$	p-value	
	N =308 n (%)	N = 316n (%)			
Mother's Highest Education			18.259		0.001
No formal education	80 (26.0)	40 (12.7)			
Primary	48 (15.6)	56 (17.7)			
Secondary	117 (38.0)	150 (47.5)			
Tertiary	33 (10.7)	35 (9.8)			
Postgraduate	30(9.7)	34(11.1)			
Father's Highest Education			13.808		0.008
No formal	28 (9.0)	10 (3.2)			
Primary	29 (9.4)	30 (9.5)			
Secondary	98 (31.8)	95 (30.1)			
Tertiary	83 (26.9)	81 (25.6)			
Postgraduate	70 (22.7)	100 (31.6)			
Mother's occupation			7.054		0.029
Professionals	70 (22.7)	100 (31.6)			
Skilled workers	154 (50.0)	131 (41.5)			
Unemployed	84 (27.3)	85 (27.0)			
Father's occupation			16.282		0.003
Professionals	127 (41.2)	176 (55.7)			
Intermediate grade	28 (9.1)	18 (5.7)			
Skilled workers	74 (24)	71 (22.5)			
Unskilled workers	2 (0.6)	2 (0.6)			
Unemployed	77 (25)	49 (15.5)			
Mother's socio-economic status			6.797		0.033
High	71 (23.1)	97 (39.7)			
Middle	149 (48.4)	152 (48.1)			
Low	88 (28.6)	67 (21.2)			
Father's socio-economic status			3.472		0.176
High	98(31.8)	104 (32.9)			
Middle	158 (51.3)	175 (55.4)			
Low	52 (16.9)	37 (11.7)			

*Statistically significant at p<0.05

Table 3. Respondents' Alcohol Consumption in Rural and Urban

Alcohol consumption	**Rural**	**Urban**	χ^2	**p-value**
	N =308n (%)	**N = 316n (%)**		
Ever consumed alcoholic drink			.168	.919
Yes	124(40.3)	140(44.2)		
No	184(59.7)	176(55.8)		
Age at first alcohol intake (year)			1.4184	.2337
< 10	4(3.6)	5(3.2)		
10-13	4(3.6)	6(4.1)		
14-16	2(1.6)	3(1.9)		
17-19	114(91.2)	126(90.8)		
Mean age at first alcohol intake				
Consumed alcoholic drink within the past 30days			.066	.967
Yes	81(26.4)	103(32.5)		
No	227(73.6)	213(67.5)		
Harmful consumption of alcohol			2.9738	.0846
Yes	20(13.7)	27(16.5)		
No	126(86.3)	137(83.5)		

Statistically significant at $p<0.05$

Table 4. Respondents Smoking Status in Urban and Rural

Smoking status	**Rural**	**Urban**	χ^2	**df**	**p-value**
	N = 308 n (%)	**N = 316 n (%)**			
Ever smoked cigarette			1.875	1	.171
Yes	16(5.2)	25(7.9)			
No	292(94.8)	291(92.1)			
Age at first smoking (years)			2.3397	2	.3104
< 10	6(37.5)	7(28.0)			
10-13	7(43.8)	7(28.0)			
14-19	3(18.8)	11(46.0)			
Mean age at first smoking	13.2 ± 2.4	11.7 ± 2.6			>0.05
Currently smoking cigarette			.913	1	.339
Yes	10(3.2)	15(4.7)			
No	298(96.8)	301(95.3)			
Mean number of days smoked in the past 30 days	5.47±9.586	0.67±0.707	t=1.487		0.150

*Statistically significant <0.05

Table 5. Fruit and Vegetable Consumption by Respondents

Fruit and vegetable consumption	**Rural**	**Urban**	χ^2	**df**	**p-value**
	N = 308 n (%)	**N =316 n (%)**			
Consumption of fruits in the past 7days			.976	1	.160
Yes	293(95.1)	292(92,3)			
No	15(4.9)	24(7.7)			
Servings of fruits per day			2.011	1	.156
< 5 servings	256(87.9)	243(83.2)			
≥ 5 servings	37(12.1)	49(16.8)			
Consumption of vegetables in the past 7 days					
Yes	271(89.7)	283(91.0)	.280	1	.596
No	31(10.3)	28(9.0)			
Servings of vegetables per day			.204	1	.651
<5 servings	248(91.6)	262(92.7)			
≥5servings	23(8.4)	21(7.3)			
Servings of fruits and vegetables					
<5 servings	289(94.5)	296(95.6)	.348	1	,555
≥ 5 servings	17(5.5)	14(4.4)			

*Statistical significance at p<0.05

Table 6. Respondents' Physical Activity, Sedentary Behaviour

Physical activity	**Rural**	**Urban**	χ^2	**df**	**p-value**
	N 308= n (%)	**N =316 n (%)**			
Physical activity (MET minutes/week) 34.390 2 <001					
Low <600	96(31.1)	54(17.1)			
Moderate 600-2,999	182(59.1)	182(57.5)			
High >3000	30(9.7)	80(25.4)			
Sedentary behavior			13.718	1	<001
No	267(86.6)	237(75.0)			
Yes	41(13.4)	79(25.0)			
***Statistically significant at p<0.05**					

Table 7. Distribution of Respondents by Blood Pressure

Blood pressure	**Frequency (%)**		$_{\chi}2$	**df**	**p-value**
	Rural n=308	**Urban n=316**			
Systolic blood pressure-for-age			3.154	3	.368
< 50th percentile (low)	157(51.0)	162(51.3)			
50th – 90th percentile (normal)	118(38.3)	132(41.8)			
90th –95th percentile (prehypertension)	19(6.2)	14(4.4)			
> 95th percentile (hypertension)	14(4.5)	8(2.5)			
Mean Systolic blood pressure	103.3±11.7	105.5±12.2	t = 2.733, p < 0.006*		
Diastolic blood pressure-for-age			4.184	3	.242
< 50th percentile (low)	175(56.8)	201(63.6)			
50th – 90th percentile (normal)	95(30.8)	76(24.1)			
90th –95th percentile (prehypertension)	24(7.8)	22(7.0)			
> 95th percentile (hypertension)	14(4.5)	17(5.4)			
Mean Diastolic blood pressure	61.1 ± 8.2	62.2 ± 8.2	t = 1.968, p < 0.049*		
High blood pressure			.722	1	.395
Yes (prevalence)	26(8.4)	21(6.6)			
No	282(91.6)	95(93.4)			

*Statistically significant Hypertensive = systolic BP > 95th percentile or diastolic BP > 95th percentile

Conflict of Interest

The authors declare no conflicts of interest related to this study.

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Association between Perceived Health Risks of Smoking and Cessation Intent among Youths in the Gambia: Global Youth Tobacco Survey (GYTS) 2017

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Abstract

Smoking is a major risk factor of noncommunicable diseases (NCDs); and as such it is important to understand and leverage on factors that influence cessation intent. This study examined the relationship between intention to quit, perceived health risks of smoking and other relevant covariates. Data obtained from 1,610 t respondents aged 11-17, who currently smoked, from the Gambian Global Youth Tobacco Survey (GYTS) of 2017 were analysed. The prevalence of intention to quit was reported by age, sex, smoking frequency, parents' and friends' smoking statuses, perceived harm of smoking and exposure to anti-smoking messages. Multivariate logistic regression was used to assess the relationship between intention to quit and the above covariates. Approximately 77.8% of adolescents, who smoked, had the intention to quit. Notwithstanding the strong association ($p<0.001$) shown at the univariate level between perceived health risks of smoking and intention to quit, the adjusted model shows no statistically significant association between the two (AOR = 1.59, 95% CI = 0.99 - 2.56). Those whose close friends currently smoked were less likely to have intention to quit compared with those who did not have any friend who smoked (AOR =3.0, 95% CI:1.34-6.74) after adjusting for other covariates. Participants exposed to anti-smoking messages; boys; and youths without friends who smoke and those who smoked the least number of cigarettes had increased odds of intending to quit smoking. These findings can guide smoking cessation strategies. Anti-smoking messages can encourage people who smoke to quit as well as discourage none smokers from initiating tobacco use.

Keywords: *Adolescents, Association, Gambia, Prevalence, Quit, Smoking.*

Introduction

As cardiovascular and other non-communicable diseases increasingly supersede communicable diseases as public health problems [2], the search for risk factors of these conditions have intensified in recent years. One such predictor is smoking. Globally, it is estimated that tobacco use accounts for a substantial number of deaths annually. In 2019 alone, close to 8 million deaths were attributed to smoking [1]. Albeit the documented global decline in the proportion of people who smoke, population increase has put the number of people who currently smoke at over 1 billion

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people around the world [2]. Without concerted and targeted interventions, it is expected that the number of people who smoke will remain high especially in developing countries where close to 80% of smoking-related deaths occurred in 2019 [3].

In Sub-Saharan Africa, there has been a 75% increase (68% for The Gambia) from 1990 in the number of people who smoke, the bulk of whom are young people who, in most cases, continue to smoke in adulthood [2-5]. A comparative age-standardized survey has found smoking to be more prevalent (1.6 times) among young people in The Gambia than their neighbouring Senegalese counterparts [2]. A school-based study conducted in 2016 found the prevalence of smoking among young Gambians 12–20-year was 16.7% [6]. Like in most developing countries, cigarette smoking in The Gambia is more prevalent among males [7,8]. Islam *et al* found that smoking initiation and prevalence were much higher among Gambian men (19.3%) than women (0.65%) ($p<0.001$) [2]. Thus, the need for current smoking cessation campaigns to mostly target young males cannot be overemphasized.

Intention to quit smoking, a cognitive variable, is an important first step in one's quest to quit smoking [9-11]. Nguyen et al has found that people who had the intention to quit smoking were more likely to do so [12]. Several factors have been found to be associated with the intention to stop smoking including smoking bans at home and public places, health messages and warnings and cessation programs. Studies conducted in both America and Vietnam explored the relationship between perceived health risks from smoking and the intention to quit among adults [13,24].

Notwithstanding the reported decline in tobacco use among young people between ages 13 and 15 in The Gambia [14], there has not been studies on factors that influence individual decisions to quit. One of the most prominent studies that sought to ascertain the association between intention to quit and perceived health risks of smoking are those conducted on the US Population Assessment of Tobacco and Health (PATH) and the Vietnamese Global Adult Tobacco Survey. Both studies were conducted on adults. The Vietnamese study found no statistically significant relationship between the two at the subgroup level. The probable reason suggested for this is the relatively small sample size of the study. The fact that the analyses were limited to males who smoke further reduced statistical power [13]. Unlike the above studies, which were adult-based, the current study will be an analysis of data on adolescents. Thus, with increased statistical power (larger sample size and the inclusion of females), this study principally sought to assess both the overall and the sex-specific relationship between perceived health risks to smoking and the intention to quit among school-going adolescents in The Gambia.

Owing to it being a cognitive variable, it has been quite challenging to establish intent to quit smoking. However, several studies have relied on self-reported "intention to quit" to quantify its prevalence among participants who smoke. Different studies have found significantly different proportions of participants who smoke but yet intending to quit – from as low as 4.7% to as high as 59.0% in studies conducted in Korea and Vietnam respectively [13, 15]. Such huge differences in prevalence could be explained by not only geographic locations but also by the fact that they are both self-reported and the age cohorts are different too.

A cross-country analysis of survey data from four Sub-Saharan African countries (Kenya, Senegal, Tanzania and Ethiopia), where over 83% of people who smoked at the time were male, found similar variations in the proportion of participants who smoked and yet intended to quit. It ranged from 23.5% in Ethiopia to 45% in both Senegal and Kenya [16]. In the Gambia, the 2017 Global Youth Tobacco Survey (GYTS) that involved school-going children between ages 11 and 17 years found that 8 out

of 10 (84.7% for boys) respondent participants who smoke intended to stop smoking [17].

In spite of the misperception among young people in Africa that smoking is the better of two evils when compared to alcohol consumption, there appears to be a high proportion of people who smoke and yet perceive smoking to be harmful to one's health [18]. A cross-sectional study on adolescents between ages 12 and 18 years found that 69.1% of young people perceived smoking a packet or more cigarettes per day to have serious health consequences [19]. A similar proportion of adolescents (60%) perceived smoking to have negative health impacts in Nepal [20] and the mean perception of absolute risk to lung cancer from smoking among Americans was found to be 48% [21].

It is estimated that low-and middle-income countries account for over 80% of the world's population, approximately 1 billion identified as people who smoke [1, 2]. Thus, it is paramount that factors that trigger or are associated with cessation decisions or the intention to quit are understood. Studies have found significant associations between intention to quit smoking and a number of factors such as smoking intensity, living in homes with smoking bans and having contact with anti-smoking information [22, 23]. It has been established that there is a strong association ($p < 0.001$) between individual perceptions of health-related harms resulting from smoking and the intention to quit [24]. Thus, given the weight of the evidence associating the intention to quit and perceptions of health-related harms of smoking found in many studies, it would be helpful to establish the degree of association of the two variables and other relevant factors in The Gambia. We assessed the association between exposure to anti-smoking messages, smoking frequency, age, parents' and close friends' smoking status with intention to quit in this study.

Research Methodology

Data Source

The study was a secondary analysis of the Gambia 2017 Global Youth Tobacco Survey (GYTS). The primary study obtained ethical approval from the relevant authorities. No ethical approval was required to gain access to the dataset as it is publicly available online.

It was a nationally representative cross-sectional survey of Gambian school-going adolescents aged 11 and 17 years [25]. The GYTS is an international partnership program involving governments, the World Health Organization (WHO) and the US Centres for Disease Control and Prevention. It uses a school-based approach that seeks to track adolescent tobacco use and the effectiveness or otherwise of recognized tobacco control measures. Under the leadership and coordination of the Ministry of Health, The GYTS was conducted in The Gambia in 2017.

A multistage sampling approach was employed to select schools for this survey, according to enrolment size, which was followed by a random selection of classrooms within the selected schools. All the students in selected classes had equal chances of participating in the survey. This resulted in the recruitment of a total of 12,585 students aged 11-17 years.

Using a standard core questionnaire, data was collected on a number of smoking-related variables. Structured, self-administered questionnaire, that required about 30-40 minutes to complete, were used to obtain data. To minimize non-response and under-reporting, all responses were made anonymous and the answer sheets were computer scannable. Field work took a duration of 6-8 weeks to complete. The main variables of interest to this study were: intention to quit and perceived health risks of smoking. We first assessed the prevalence of "intention to quit" among respondents who perceived smoking to have health risks; and those exposed to anti-

smoking messages among respondents who smoked at the time. The prevalence of intention to quit was also estimated along the categories of sex, smoking frequency, age and the smoking statuses of parents and close friends of participants. This ultimately enabled us to establish the degree of association between the two variables by conducting both univariate and multivariable logistic regression analyses. Other variables that were included in the model are age, parents' and close friends' smoking status, exposure to anti-smoking messages, sex and smoking frequency.

Sample Size Determination and Eligibility Criteria

The eligibility criteria for the current study included that out of the 12,585 students in the GYTS survey, a respondent must be male or female between ages 11 and 17 years; and be a person who currently smoked (defined as having smoked in the last 30 days) at the time of the study. The exclusion criteria included people who did not meet the precedent inclusion criteria (Figure 1). Thus, the sample size for this study is 1,610 adolescents between ages 11 and 17 years.

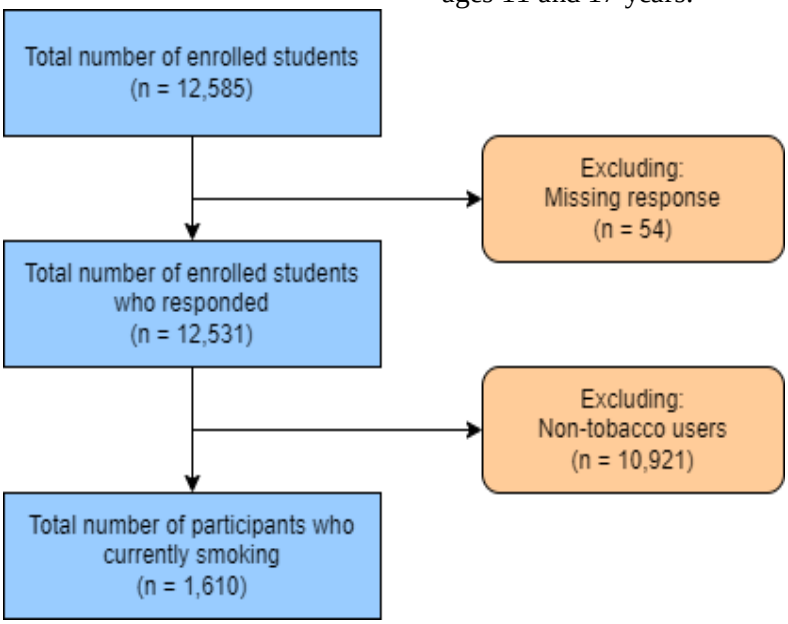

Figure 1. Flowchart of Participant Selection (Global Youth Tobacco Survey (GYTS) 2017)

Statistical Analysis

Statistical analyses were performed using STATA (version 18). Descriptive analyses were conducted for each and every study variable. Rates are reported as percentages with their corresponding 95% confidence intervals. Furthermore, univariate and multivariate regression analyses were conducted to assess the relationship between intention to quit (as a dependent variable) and perceived health risks of smoking, exposure to anti-smoking messages, smoking frequency, parents' and close friends' smoking status. P-values more than 0.05 or confidence intervals that embrace the null are considered statistically insignificant.

In order to obtain information on potential confounders, data collected on demographic and other baseline variables from each study subject was included in the regression model. Collinearity of individual-level variables was considered prior to inclusion in the model and it resulted in the exclusion of the "Age at smoking initiation" variable. Some of the variables included are: smoking status, age and sex. To adjust for the complex nature of the study design, we applied Stata's Svy command [4] to apportion sampling weights in order to determine true prevalence and stratify cluster variables.

Results

Demographic Information and Characteristics of the Participants

The demographic and other basic characteristics of the study participants are described in Table 1 below. The sample, comprise of 1,610 school-going adolescents (65.4% boys, 34.6% girls) and their ages ranged from 11 to 17 years, with over 50% aged between 14 to 16 years old.

Table 1. Participant Characteristics, Global Youth Tobacco Survey–AFRO, Gambia All Schools, Regions 1-6, 2017

	Unweighted frequency	Weighted percent (95% CI)
Sex		
Male	1013	65.4 (61.0-69.5)
Female	536	34.6 (30.5-39.0)
Missing	61	
Age		
≤11 Years Old	47	3.1 (2.2-4.3)
12 years Old	89	5.8 (4.4-7.4)
13 years Old	169	10.9 (8.9-13.4)
14 years Old	317	20.5 (17.4-24.0)
15 years Old	274	17.7 (15.0-20.8)
16 years Old	270	17.4 (14.8-20.4)
≥17 years Old	381	24.7 (20.7-29.1))
Missing	64	
Smoking Frequency		
None®	615	44.9 (39.7-50.1)
<1 Cigarette/Day	414	30.2 (25.3-35.6)
1 to 5 Cigarettes/Day	282	20.6 (17.1-24.5)
6 to 10 Cigarettes/Day	39	2.9 (1.8-4.6)
11 to ≥20 Cigarettes/Day	21	1.5 (0.9-2.8)
Missing	240	
Parents' smoking status		
None	994	63.1 (59.2-66.9)
Both	87	5.5 (4.2-7.3)
Father Only	273	17.3 (14.5-20.6)
Mother Only	91	5.8 (4.4-7.5)
Don't Know	130	8.3 (6.3-10.7)
Missing	36	
Close friends' smoking status		
None	745	48.2 (44.3-52.1)
Some	554	35.9 (33.1-38.8)

	Unweighted frequency	Weighted percent (95% CI)
Most	169	11.0 (8.5-14.1)
All	76	4.9 (3.7-6.5)
Missing	66	
Exposure to Anti-Smoking Messages		
Yes	771	52.3 (47.8-56.9)
No	702	47.7 (43.1-52.2)
Missing	137	
Intention to Quit		
Yes	693	77.8 (71.1-83.3)
No	375	22.2 (16.7-28.9)
Missing	542	
Perceived harm from smoking		
No	724	47.3 (42.4-52.3)
Yes	808	52.7 (47.8-57.6)
Missing	78	
(N=1,610)		

Prevalence of Intention to Quit Among Gambian Students who Smoke

The prevalence of some of the potential predictors of intention to quit smoking considered in the analyses was: 30.5% (95% CI: 25.5% - 36.0%) of men and 15.9% (95% CI: 11.8% - 21.0%) of women; 30.3% (95% CI: 24.5% - 36.7%) of those exposed to anti-smoking messages and 22.2% (95% CI: 18.2% - 26.8%) of those unexposed to anti-smoking messages; and 30.8% (95% CI: 24.6% - 37.8%) of tobacco users who perceive that smoking has harmful health consequences and 21.7% (95% CI: 17.2% - 27.1%) of those who do not hold such a perception. The prevalence of intention to quit for the rest of covariates are as presented in Table 2.

Factors Associated with Intention to quit Smoking among Gambian Students

At the univariate level, all but one independent variable exhibited a statistically significant relationship, for at least one of its categories, with intention to quit. The only factor that did not show any statistical significance in any of its categories is age. Factors with the strongest statistical significance in the univariate analysis (Table 3) are sex, perceived harm from smoking, close friends' smoking status and smoking frequency.

In our multivariate regression model, the factors strongly associated with intention to quit (statistical significance at least $p<0.01$) include sex, smoking frequency, close friends' smoking status and exposure to anti-smoking messages. However, among the responses on participants' close friends' smoking status, statistical significance was recorded for only those who had all their close friends as tobacco users albeit being non-statistically significant at the univariate level. While exposure to anti-smoking messages remained slightly associated with intention to quit, perceived harm from smoking did not turn out to be statistically significant after adjusting for other covariates in

the multivariate analysis. The age of adolescent tobacco users has consistently (at both univariate and multivariate levels) been found not to be associated with intention to quit.

Table 2. Prevalence of Intention to Quit Smoking Among Gambian Students who Smoke, Global Youth Tobacco Survey – AFRO, Gambia All Schools, Regions 1-6, 2017

	Unweighted sample n	**Intention to Quit % (95% CI)**
Sex		
Male	1013	30.5 (25.5-36.0)
Female	536	15.9 (11.8-21.0)
Age		
≤11 Years Old	47	37.1 (23.0-53.7)
12 years Old	89	21.1 (11.6-35.2)
13 years Old	169	27.4 (16.8-41.4)
14 years Old	317	27.1 (17.2-39.8)
15 years Old	274	20.4 (13.9-29.1)
16 years Old	270	21.7 (15.4-29.7)
≥17 years Old	381	27.3 (20.5-35.5)
Parents' smoking status		
None	994	25.2 (21.1-29.8)
Both	87	16.0 (8.2-28.8)
Father Only	273	36.7 (27.3-47.2)
Mother Only	91	27.3 (16.3-42.1)
Don't Know	130	14.5 (8.5-23.7)
Close friends' smoking status		
None	745	19.1 (14.0-25.7)
Some	554	33.1 (27.4-39.3)
Most	169	34.9 (25.8-45.3)
All	76	24.1 (14.1-38.1)
Exposure to Anti-Smoking Messages		
Yes	771	30.3 (24.5-36.7)
No	702	22.2 (18.2-26.8)
Perceived harm from smoking		
No	724	21.7 (17.2-27.1)
Yes	808	30.8 (24.6-37.8)
Smoking Frequency		
None	615	10.0 (6.8-14.6)
<1 Cigarette/Day	414	40.9 (32.6-49.7)
1 to 5 Cigarettes/Day	282	39.5 (32.2-47.4)
6 to 10 Cigarettes/Day	39	19.0 (6.9-42.6)
11 to ≥20 Cigarettes/Day	21	31.9 (16.0-53.6)
(N=1,610)		

Table 3. Factors Associated with Intention to Quit Smoking among Gambian Students who Smoke, Global Youth Tobacco Survey – AFRO, Gambia All Schools, Regions 1-6, 2017

Variable	Unweighted sample n	Intention to Quit	
		OR (95% CI)	AOR (95% CI)
Sex			
Male®	1013	1	1
Female	536	0.30 (0.22-0.42**)**	0.50 (0.33-0.76)
Age			
≤11 Years Old®	47	1	1
12 years Old	89	0.66 (0.26-1.67)	0.72(0.26-1.99)
13 years Old	169	0.81 (0.30-2.17)	0.77 (0.21-2.85)
14 years Old	317	0.80 (0.32-2.02)	1.09 (0.31-3.81)
15 years Old	274	0.96 (0.41-2.25)	0.93 (0.28-3.07)
16 years Old	270	1.09 (0.44-2.69)	0.81 (0.21-3.22)
≥17 years Old	381	1.55 (0.66-3.62)	1.22 (0.40-3.67)
Parents' smoking status			
None®	994	1	1
Both	87	0.84 (0.51-1.39)	1.17 (0.47-2.92)
Father Only	273	1.68 (1.06-2.64) *****	1.64 (0.89-3.015)
Mother Only	91	0.72 (0.38-1.36)	0.72 (0.34-1.52)
Don't Know	130	0.54 (0.31-0.93) *****	1.26 (0.60 -2.656)
Close friends' smoking status			
None®	745	1	1
Some	554	2.66 (2.00-3.52)	1.15 (0.77-1.73)
Most	169	3.33 (1.82-6.08)	2.01 (0.76-5.30)
All	76	1.40 (0.74-2.62)	3.01 (1.34-6.74)
Exposure to Anti-Smoking Messages			
Yes ®	771	1	1
No	702	0.70 (0.55-0.90) *** ***	0.66 (0.44-0.99) *****
Perceived harm from smoking			
No ®	808	1	1
Yes	724	1.83 (1.35-2.48)	1.59 (0.99-2.56)
Smoking Frequency			
None®	615	1	1
<1 Cigarette/Day	414	25.30 (13.60-47.05)	21.10(11.15-
1 to 5 Cigarettes/Day	282	30.40 (11.34-81.45)	18.86 (6.79-52.36)
6 to 10 Cigarettes/Day	39	16.85 (5.20-54.67)	7.46 (2.00-27.91)
11 to ≥20 Cigarettes/Day	21	12.39 (2.77-55.415)	29.02(5.21-61.76)
(N=1,610)			

® *Reference: * p<0.05, ** p<0.01, *** p<0.001*

Discussion

Smoking is one of the major risk factors of cardiovascular and other noncommunicable diseases (NCDs) and as such cessation of the practice significantly reduces the risks of such outcomes [2]. Several factors could potentially influence the intention to quit smoking [9-13]. However, there is paucity of data on the predictors of intention to quit in The Gambia and other sub-Saharan African countries. This study principally sought to assess the association between perceived health risks of smoking and intention to quit. The relationship between other potential factors of cessation intent and intention to quit was also assessed.

Diminished statistical power, arising from the relatively small number of respondents who admitted to being current tobacco users (1,610) and the high non-response rate to smoking-related questions, may have played a part in not finding statistically significant relationships between quit intention and some variables [27]. The high non-response rate of participants on smoking-related questions has led to the loss of a considerable number of observations. The Gambia being a conservative society [28], where adolescent smoking is regarded as a wayward behaviour, such non-response rate is not a surprise. Furthermore, since the inclusion criteria of this study confined participation to school-going adolescents between ages 11 and 17 years, generalization of the findings to the general population should be done with caution. Difficulty in establishing temporality between intention to quit and perceived harm or any of the covariates considered in the analysis is another limitation of the study.

In the current study, approximately 77.8% of adolescents (30.5% of boys and 15.9% of girls), who smoked, had the intention to quit. Different studies found significantly different proportions of participants who smoke but yet intending to quit – from as low as 4.7% to as high as 59.0% in studies conducted in Korea and Vietnam respectively [13, 15]. Such huge differences in prevalence could be explained by not only geographic locations but also by the fact that they are both self-reported and the age cohorts are different too.

Notwithstanding the strong association ($p<0.001$) shown at the univariate level between perceived health risks of smoking and intention to quit, the adjusted model shows no statistically significant association between the two (OR = 1.59, 95% CI = 0.99 - 2.56). This is somewhat consistent with the findings of the Vietnamese Global Adult Tobacco Survey, at the subgroup level, where it was found that perceived harm from tobacco use was not necessarily associated with intention to quit among waterpipe or dual users and the authors cited low statistical power as the likely cause [13]. Despite the discordance of the age groups between the two studies, the sample sizes are not very different (1,610 versus 1,351). However, the bulk of studies with significantly bigger sample sizes found the reverse at the multivariate level – that there is a strong association between perceived harm from smoking and intention to quit [13,28,290]. Thus, there is a need for a bigger study with a wider age range to assess the association between intention to quit and perceived harm from smoking.

Exposure to anti-smoking messages, sex and smoking frequency were the only independent variables that consistently exhibited statistical significance (at least $p<0.05$) in their association with intention to quit at both the univariate and multivariable levels. Previous studies corroborate these findings [22, 23, 29, 30]. The age of an adolescent has in both univariate and multivariable models consistently shown not to be associated with intention to quit. While this finding is consistent with a previous finding [31], another study found the reverse [22].

Our findings highlight significant factors influencing youth smoking cessation intentions. Specifically, youth with close friends who smoke are less likely to intend to quit, suggesting the powerful role of social networks

in shaping smoking behaviours. A previous study using the same data found that youth who had friends that smoke was more likely to experiment cigarette smoking compared with those who did not [32]). Conversely, exposure to anti-smoking messages, being male, having fewer smoking peers, and smoking fewer cigarettes are positively associated with intentions to quit. These results underscore the need for further investigation into the social dynamics of smoking among youth, particularly the influence of peer networks on smoking cessation intentions. Future research should explore interventions that disrupt these social reinforcements, such as peer-led smoking prevention programs, while examining gender differences in smoking behaviours and cessation motivations. Policymakers should prioritize anti-smoking campaigns targeting youth, with a focus on increasing exposure to anti-smoking messages through schools, social media, and community programs. Policies could also benefit from incorporating strategies to weaken peer influence, such as fostering smoke-free environments and promoting peer support systems for cessation. Comprehensive tobacco control measures, including higher taxes on cigarettes and restrictions on youth access to tobacco products, remain critical to reducing smoking prevalence and facilitating cessation efforts among young populations. This multidimensional approach can help curb smoking initiation and support quitting intentions, ultimately reducing the public health burden of tobacco use.

Conclusion

The results of the study suggest that youths/adolescents exposed to anti-smoking messages compared to those not exposed to such messages; boys compared to girls; and those who smoked the least number of cigarettes had increased odds of intending to quit smoking. Prioritizing anti-smoking campaigns targeting youth, with a focus on increasing exposure to anti-smoking messages through schools, social media, and community programs could be effective in encouraging cessation among people who currently smoker and preventing cessation among those who don't smoke.

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Conflict of Interest

We have no conflict of interest to declare.

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The Price of Transparency: How Exposing Personal Information in Mobile Money Transactions Fuels Social Engineering in Ghana

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Abstract

Communications technologies such as 2G, 3G, 4G and 5G define a significant portion of today's cyberspace and has attracted innovative value-added services and financial technologies such as mobile money (MM) transactions. The success of MM introduction in Kenya has significantly influenced its global adoption in other developing countries, such as Ghana. While MM systems are widely studied for their economic transformation impact within the Ghanaian context, this paper hypothesised that, there is limited research on its contribution to widening the attack surface of social engineering (SE) attacks as a result of its exposure of personally identifiable information (PII) during transactions. The paper explored the hypothesis with a quantitative methodology adopted with primary data collected through questionnaires designed to capture user experiences, perceptions, and insights on privacy and security concerns during MM transactions. The findings confirmed the hypothesis: 96.7% of respondents acknowledged that their PII is visible to recipients during transactions, and 76.7% believed this exposure increases their vulnerability to scams. Additionally, 48.3% reported experiencing phishing attempts or suspicious behaviour where their PII was referenced after MM transaction.

Keywords: *Cyberspace, Mobile Money, PII, Social Engineering.*

Introduction

The evolution of cellular technology has rigorously gone through a remarkable transformation from the initial less complicated service rendering second generation technology(2G) to the more contemporary advanced fifth generation technology(5G) that underpins today's thriving mobile communications landscape. These communications technologies define a significant portion of today's cyberspace and has attracted innovative value-added services and financial technologies such as mobile money transactions. It's worth noting that, the growth of mobile technology has led to the development of various cashless transaction options worldwide [1]. Mobile money gained global prominence, particularly, after its introduction in Kenya as M-PESA [2]. The success of M-PESA has significantly influenced the adoption of mobile services in other developing countries, such as Ghana.

While mobile money systems are widely studied for their economic transformation impact within the Ghanaian context, there is limited research on its contribution to widening the attack surface of social engineering (SE) attacks as a result of its exposure of personally identifiable information (PII) during transactions. This gap arises as a result of exposure of PII, such as full names linked to mobile numbers, during transactions in the name of transparency. Quite notably, the ease with which users could have access to names associated with phone numbers, either through completed transactions or preliminary attempts, has been largely overlooked in existing studies. This paper identifies this aspect of the mobile money transaction processes as overlooked and it poses a considerable risk such as identity

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theft, impersonation fraud, and unauthorised data harvesting.

Reconnaissance is an important aspect of military planning operations because it strategically helps to understand the enemy. The reconnaissance operation systematically involves identifying and analysing the potential target in order to exploit its weaknesses [3]. For instance, in a likened case study, reconnaissance was carried out to measure security awareness of employees by revealing discrepancies between their understanding and actual behaviour during penetration in a penetration test. This highlights the importance of reconnaissance in identifying and exploiting human vulnerabilities [4]. Moreover, in [5], reconnaissance is regarded as a critical phase in the cyber kill chain, where adversaries gather information to exploit vulnerabilities in systems and people; this phase is essential for the success of subsequent attacks. Building on this, this paper further theorises that, the mobile money (MM) platforms in Ghana might be increasing the reconnaissance surface for information gathering.

A quantitative methodology was adopted with primary data collected through questionnaires designed to capture user experiences, perceptions, and insights on privacy and security concerns during MM transactions. This research though is region-specific and localised, it is intended to add unique knowledge to a global discourse on SE within the context of mobile money transactions security.

The PII Concept

Our online digital footprints, could be likened to secret keys that qualifies to be used to unlock personal information about us, be it our name, location, phone number, preferences and the rest. With the advent of personal data breaches and its antecedent cyber security concerns, Personally Identifiable Information (PII) has assumed a centre stage in data protection discussions due to its implications for individual privacy and the security of sensitive data. In [6], PII is defined as any information that can be used independently or in combination with other information to identify an individual; and the paper further highlighted the components of PII as names, social security numbers, dates and places of birth, MAC addresses, phone numbers and other identifiers that can trace an individual's identity. The growing importance of PII could be attributed to the rise of digital technologies and the increasing amount of personal data collected by organisations across wide range sectors of our daily lives, i.e., from online games, healthcare, finance, social media, e-commerce and the rest [7]. The need for robust protection measures regarding PII is adequately emphasised in existing literature, largely driven by concerns over data breaches and identity theft. Privacy is not merely a personal concern but a societal issue, where the misuse of PII can lead to significant harm, including financial loss, reputational damage, or potential social manipulation [8].

Various dimensions of PII protection, from legal frameworks to technological solutions are continuously being explored by researchers. Regarding legal frameworks, the "European Union’s (EU) General Data Protection Regulation (GDPR)" represents a landmark legal initiative aimed at strengthening the protection of PII that mandates explicit consent for data collection and providing individuals with the right to access, correct, and delete their personal data [9].

Ghana's data protection act, 2012(Act 843) is a legislation that plays an important role for protecting individual data and privacy. The legislation establishes the “Data Protection Commission (DPC)”, which is responsible for regulating the processing of personal information and ensuring individuals' privacy rights are upheld. The role of DPC in Ghana compares to the GDPR's tenets regarding safeguarding individuals PII against digital crimes [10].

The use of technology to tackling the challenges of PII is also an ongoing approach being explored by researchers. Quite a number of technological approaches such as cryptographic methods, data anonymisation, pseudonymisation, and encryption have all been put forward as effective techniques to protecting PII from unauthorised access. However, as challenges associated with PII evolves in complexity, some scholars have argued that these enumerated approaches are quite insufficient at addressing the emerging risks. It is argued that artificial intelligence algorithms especially in the domain of machine learning have the capability of de-anonymising data through pattern recognition thereby making traditional anonymisation techniques less effective [11].

Quite a number of gaps could be identified in current technological approaches to managing and securing PII. Firstly, while data masking is widely utilised to securing PII, it often results in inefficiencies during data analysis. Moreover, the application of machine learning systems at securing PII is bedevilled with notable error rates, particularly when these systems are employed across various regions. Additionally, although encryption and masking techniques are essential for enhancing data security, they introduce complexity and elevate costs associated with data transactions. Furthermore, traditional manual methods for tagging and securing PII are becoming increasingly impractical due to the sheer volume of data generated today. Lastly, there is a pressing demand for cost-effective automated techniques that require minimal data transformation while still providing strong security and privacy for PII [12].

Social Engineering

Social engineering (SE) is conceptually not technical in nature but rather leverage manipulating humans who are perceived to having what the attackers are in search of by persuading the target to unknowingly make available sensitive data or inadvertently aid the attack by performing certain actions [13] [14]. A plethora of methodologies and tactics are employed by attackers in their successful SE trade. All these SE attacks are performed based on harvested personal information of victims.

The risks associated with breach of personal information could range from minor disturbances to serious threats. However, this very personal data could also be leveraged to improve services, streamline interactions, and facilitate communication with interactive systems. Ironically, interactive systems are increasingly being designed with personal information as a critical element in areas such as e-commerce, healthcare, office work, and personal communications; this is a fundamental challenge [15].

The mobile Money platforms, this paper believes increases the attack surface for harvesting personal information. By design, the objective of SE attacks is basically to get hold of sensitive data, including PII, from their target.

In [16], a detailed classification system for social engineering attacks were presented as structured around several key components. Notable amongst them is the attack scenario class in which SE attacks could take place over multiple channels including human or software operators. Additionally, attacks could be classified into physical, technical, social, or socio-technical. The human factor channel has notoriously gained popularity in recent times.

In an annual Internet Crime Report for 2023, the FBI's Internet Crime Complaint Centre (IC3) made known phishing as the most frequently reported crime. The report pointed out a record number of complaints (i.e., 880,418) with potential losses exceeding $12.5 billion. Phishing/Spoofing accounted for over 34% of all the complaints [17]. This highlights the prevalence of phishing where attackers impersonate legitimate individuals or entities through the channels earlier enumerated to gain

unauthorised access to sensitive data; this calls for action to minimise the attack surface.

Phishing

Phishing is described as an attempt at acquiring sensitive information such as usernames, passwords, and credit card details by perpetrators masquerading as trustworthy entities in an electronic communication. The approaches employed often involve communication that appears to be from a reputable source such as social media sites, auction platforms, or IT administrators, basically aimed at deceiving the unsuspecting individual [18, 19]. Notably, researchers have increasingly been focusing on understanding the mechanisms, psychological factors, and defence strategies against phishing in recent times. At the genesis of all of these, phishing attacks were primarily executed via email channels but contemporarily, phishing has extended to various digital platforms, including social media, SMS (smishing), and phone calls (vishing).

Role of PII in Phishing

Phishing is considered as a cybercrime activity that exploits PII, with the objective of deceiving individuals into giving away sensitive data. In [20] names and phone numbers were identified as PII, and PII theft was described as the unlawful acquisition of such PII qualifiers for malicious economic gain. Phishing kits are often used in attempts to gather PII such as email addresses, passwords, geolocation, and phone numbers. This highlights the significance of PII in phishing expeditions [21]. Additionally, the use of fake emails, websites, and messaging are among the channels commonly employed by phishers to masquerade as trusted sources, thereby tricking their victims into unknowingly providing their PII [22].

Materials and Methods

Research Design

This study adopted a quantitative research design to systematically investigate the exposure of personally identifiable information (PII) during mobile money transactions and its implications for social engineering attacks in Ghana. For its ability to provide reliable measurable data that effectively allows for statistical analysis and inferred generalisation, the quantitative approach was chosen. To align positively with the paper's objective, the following quantifiable key variables were the focus of the design i.e., user awareness, perceptions of vulnerability, and recommendations for privacy improvements.

Research Instruments

An online questionnaire was used as the primary research instrument for data collection. The questionnaire was designed to include both closed-ended and multiple-choice questions. Key questions were focused on:

1. Awareness of PII exposure during mobile money transactions.
2. Perceived vulnerability to scams and attacks due to PII exposure.
3. User preferences for privacy-preserving features in mobile money platforms.
4. Opinions on the adequacy of public awareness campaigns addressing social engineering risks.
5. Recommendations for mitigating mobile money fraud and social engineering attacks.

Table 1. Summary of Key Questions Relevance

Question	Purpose & Relevance
Are you aware your full name and phone number are visible to any recipient in mobile money transactions?	To assess users' foundational level of awareness about PII exposure during mobile money transactions.

Do you think the exposure of your full name and phone number during mobile money transactions makes you more vulnerable to scams or attacks?	To evaluate users' perceptions of how PII exposure increases their susceptibility to scams and social engineering attacks.
Would you feel safer if your mobile money transactions did not expose your full name and phone number to the recipient?	To understand users' preferences for privacy-preserving features in mobile money platforms.
Do you think that there is enough public awareness about the risks of social engineering and scams related to mobile money?	To gauge the perceived adequacy of public education and awareness campaigns addressing mobile money-related risks.
What do you think is the most effective way to prevent mobile money fraud and social engineering attacks in Ghana? (Select one or more options)	To identify user-driven recommendations for mitigating mobile money fraud, such as improved privacy measures or education.

Table 1 is a summary of the relevance of the key questions posed.

Data Collection Procedure

Electronic data collection procedure was used by leveraging digital platforms to distribute a questionnaire. This data collection method was adopted because of its efficiency, scalability, and accessibility at allowing respondents to participate at their convenience. Appropriately, this approach is quite effective at reaching the technologically adept target group and minimising logistical costs. Basically, research findings should be generalisable to the population from which the sample is drawn i.e., the sample must accurately represent the population [23]. In Ghana, online activities are largely driven by Subscriber Identity Module (SIM) card and the market share per operator is represented as 75%-MTN, 15%-Telecel, and 10%-AT [24]. These values, largely align with the distribution of questionnaire respondents per operator to which mobile money platform (MMP) respondents are on i.e., 68.90%-MTN, 23%-Telecel, 4.9%-AT, and 1.6%-GCB Mobile Money. It is worth noting that, users legitimately have multiple SIM cards and could opt for any MMP usage at any time convenient.

The use of paper-based forms for data capturing and subsequent entry into an electronic system is traditionally well established. On the other hand, it is quite easier to engage real-time data capture and analysis electronically. Largely, electronic data capture systems offer greater time efficiency and also enhance accuracy compared to paper-based methods [25].

Results & Discussion

MM & Personal Data Harvesting

For household garbage collection, this author relies on a private service provider that is not a registered entity and is unknown to the state. This type of service provider is common within the Ghanaian community. In the event of any incident where the service provider might be implicated, how would the state be able to trace this unregistered entity? To gain access to their contact information, I initiated a feigned payment through mobile money, which required the service provider to granted me their phone number. Once I had the number, I was easily able to retrieve the associated full name through the mobile platform. This demonstrates how easily personal data, such as mobile numbers and accompanying names, could be collected via mobile money services.

Age Group

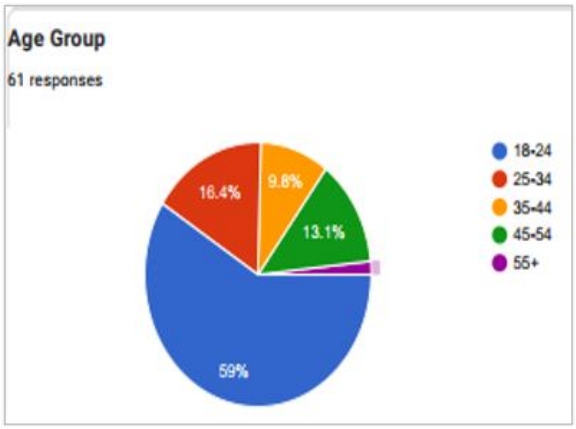

Figure 1. Age Group

The questionnaire garnered 61 responses with one not a user of MM service. 85.2% of the respondents were in the age group of 18-44 as in Figure 1 above.

As pointed out in [26], familiarity with technology varies quite significantly across age groups; usually, younger generations favour interactive media and online platforms for information and entertainment based on their acquired digital skills. In contrast, older generations go for traditional media due to lower digital literacy [27]. This implies that, drivers of mobile money growth in Ghana are the youth.

MM Usage Frequency

User behaviour, dependence on MM platform, potential exposure to SE risk, and likelihood of targeted vulnerability were put to test as captured in Figure 2 below.

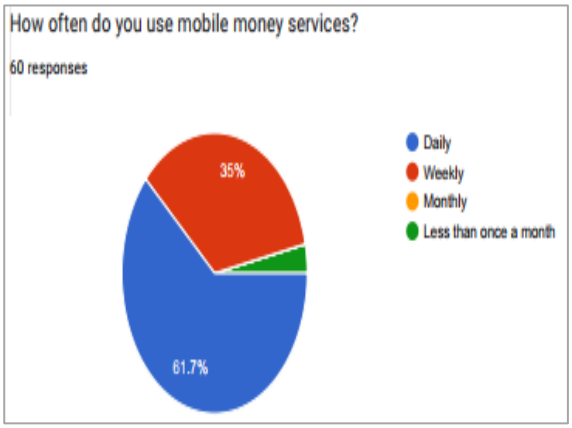

Figure 2. MM Usage Frequency

The MM platform forms an integral part of about 96.7% of the respondents' financial transactions on a daily and weekly basis. This inadvertently could provide SE attackers a repeated opportunity to harvest users PII i.e., full names and corresponding phone numbers. This opportunity could heighten the likelihood of tailored SE schemes, such as phishing or impersonation attacks.

Awareness & Vulnerability Perception

A study by Lappeman et al. highlights a significant level of digital privacy concern amongst consumers regarding how their PII is handled by chatbots. This concern is heightened by high-profile data breaches incidents such as the Cambridge Analytica-Facebook event, which in turn has raised awareness about data

privacy issues. Their research found that, privacy concerns negatively impact users' willingness to disclose PII to chatbots. This concern indicates that, even if consumers are aware of the benefits of using chatbots, their apprehensions about privacy can hinder their engagement [28]. This assertion by Lappeman et al collaborates one of the key findings of this paper i.e. user awareness of inherent risks in MM transaction.

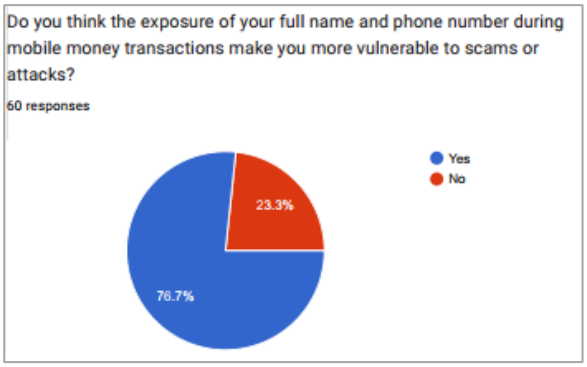

Figure 3. Vulnerability Perception

A 96.7% respondents awareness regarding PII exposure during MM transaction was recorded. In addition, a 76.7% felt this exposure places them at greater risk as in Figure 3 above. This perceived risk aligns with the paper's objective of theorising an expanded SE attack surface in MM platforms.

Social Engineering Risks

Table 2. SE Risk

Question ID	Question Text	Response Option-1	Response Option-2	Response Option-3
Q10	Have you ever experienced any suspicious behaviour or phishing attempts after making a mobile money transaction, where the attacker referenced your name or phone number?	Yes [48.3%]	No [51.7%]	
Q11	Would you feel safer if your mobile money transactions did not expose your full name and phone number to the recipient?	Yes [38.3%]	No [53.3%]	Maybe [45%]
Q12	Have you ever reported a fraudulent mobile money transaction or social engineering attempt to the service provider?	Yes [38.3%]	No [16.7%]	I didn't know I could report it [8.3%]
Q13	Do you think mobile money providers should do more to protect users	Yes, a lot more [81.7%]	Yes, somewhat [13.3%]	No, they are doing enough [5%]

	from scams and social engineering attacks?			
Q14	Do you think that there is enough public awareness about the risks of social engineering and scams related to mobile money?	Yes [28.3]	No [65%]	Maybe [6.7%]

This section focuses on SE risks per user experience in connection with the MM platform. The analysis is based on the responses in Table 2 above. Quite significantly, almost half (48.3%) of the respondents reported experiencing suspicious behaviour or phishing attempts where their PII i.e., name or phone number, was referenced. This implies that, a substantial proportion of users have already faced potential SE attempts after MM transaction. A slight majority i.e., 51.7% reported no such experience as of yet. But, the values recorded for Q10 “Yes” and “No” responses were almost equally split suggesting the pervasiveness of the risk but not universally recognised.

With respect to Q11, 38.3% explicitly felt that, masking their PII during MM transactions would make them safer but a majority i.e., 53.3% did not share this sentiment. In addition, 45% were uncertain; this indicates a divergence in user perceptions of the link between PII exposure and SE risks. Per the response data, many users might not be in the position to fully appreciate the implications of PII exposure in enabling social engineering attacks.

Q12: A notable 38.3% of the respondents has once made an attempt at reporting fraudulent SE attempts. This demonstrates that, many users actively come to face and somewhat recognise such threats. However, the 8.3% who were unaware they could report such incidents points to lack of awareness about reporting channels. The 16.7% who did not attempt at making any report might point to doubt about the effectiveness of embarking on such exercise.

Q13: Overwhelmingly, 81.7% of the respondents felt owners of MM platforms should do more at protecting users. This assertion was supported by an additional 13.3% expressing a moderate agreement. Notably, only 5% were of the believe that, the existing measures in place are adequate. This highlights an obvious dissatisfaction with the existing security provisions. The responses further underscore a strong demand for improved security measures, such as masking PII during MM transactions. This aligns with the study's objective of minimising the attack surface of the current system's design. The response also reflects users' awareness of the need for systemic solutions to address vulnerabilities in the MM platforms.

Q14: Majority of the respondents i.e., 65% were of the opinion that, there is insufficient public awareness about the risks associated with SE and scams regarding the MM domain. In contrast, 28.3% felt there is enough awareness. However, a 6.7% expressed uncertainty about the effectiveness of current awareness efforts. The findings highlight a significant gap in public education and awareness campaigns, which is a very important knowledge users must have to help them recognise and prevent SE attacks. Furthermore, the role of MM providers, regulators, and policymakers at designing and implementing effective awareness campaigns to bridge this knowledge gap is called into question. This paper posits that, the lack of

awareness contributes to the vulnerabilities created by PII exposure, making users easy targets for SE attacks.

This section's responses point to a substantial incidence of PII related threats and a widely perception that existing protection measures in the MM platform domain are inadequate. This calls for a systemic change which is strongly supported by the findings and the paper's hypothesis that MM transaction processes as currently designed increases the attack surface for social engineering. There was also a call for public awareness about SE risk that brings to the fore a needed drive for user education as a central component of the solutions of the identified risks. A multiple response question in Figure 4 below reinforces the emphasis on the importance of public education campaigns. This garnered the highest percentage of 60% which underscores the recognition awareness plays in equipping users to appreciate SE schemes.

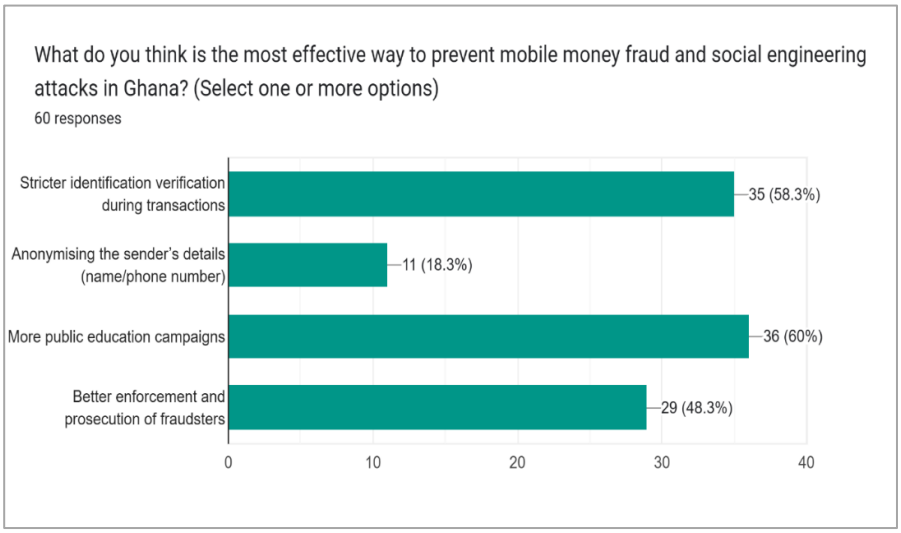

Figure 4. User-Perceived Solutions

The spread of the responses, as captured in Figure 4 above, suggest that no single solution could effectively deal with the problem but rather a solution that encompasses stricter verification, education, enforcement, and possibly anonymisation. In contrast, respondents lower prioritised data anonymisation which this paper considers as one of the key solutions to resolving the PII exposure problem. This implies that, respondents either undervalued the role of data anonymisation at reducing the SE attacks or are less informed about its potential impact. Anonymisation techniques, such as the dynamic anonymity privacy-preserving model, help to reduce information loss and can potentially improve data usability by processing data across multiple granularity spaces and applying differential privacy principles [29]. In the context of cloud services, as demonstrated by the Clustering Permutation for data Anonymisation (CPA), anonymisation ensures that data privacy is maintained without altering the context of the data, thus supporting compliance with privacy laws [30].

Conclusion

The outcome of this paper reaffirms a critical vulnerability within Ghana's MM ecosystem. The MM platform's design exposes users' PII, specifically their full names and phone numbers thereby creating a fertile ground for SE attacks. By making such data readily accessible during MM transactions, the MM platforms inadvertently expand the attack surface for fraudsters — aligning strongly with the hypothesis that, MM platforms by their current design, heighten the attack surface for SE.

The major outcomes of the study revealed a complex interplay of awareness, risk

perception, and security gaps. While most users recognise the visibility of their PII and its potential for misuse, a troubling disconnect persists between this awareness and their trust in the platform's safety. Alarmingly, nearly half of the respondents reported being targeted by phishing attempts referencing their PII after MM transaction, and a majority acknowledged the need for greater protections. Yet, despite these risks, many remain quite hesitant about the adoption of certain preventative measures, such as anonymising sender details; an indication of both cultural trust in the system and insufficient understanding of how social engineering operates.

Yet, the deeper question remains; how far could technological and educational interventions go in mitigating risks that are embedded within the very structure of MM platforms? Are MM platform owners thus willing to fundamentally reengineer their systems to prioritise user anonymity without compromising transparency and convenience?

Conflict of Interest

I, Daniel Adjei Odai, hereby declare that, there are no conflicts of interest regarding this research work.

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