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Light RAT-SQL: A RAT-SQL with More Abstraction and Less Embedding of Pre-existing Relations

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Abstract

RAT-SQL is among the popular framework used in the Text-To-SQL challenges for jointly encoding the database relations and questions in a way to improve the semantic parser. In this work, we propose a light version of the RAT-SQL where we dramatically reduced the number of the preexisting relations from 55 to 7 (Light RAT-SQL-7) while preserving the same parsing accuracy. To ensure the effectiveness of our approach, we trained a Light RAT-SQL-2, (with 2 embeddings) to show that there is a statistically significant difference between RAT-SQL and Light RAT-SQL-2 while Light RAT-SQL-7 can compete with RAT-SQL.

Keywords: *Deep learning, Natural Language Processing, Neural Semantic Parsing, Relation Aware Transformer, RAT-SQL, Text-To-SQL, Transformer.*

Introduction

The RAT-SQL [1] has been used in Text-to-SQL [2-4] as an encoder transformer. The RAT-SQL framework jointly encodes the question and the schema database to improve the generalization even in unseen databases by the model during the training process. RAT-SQL is based on the relation-aware self-attention mechanism, and address schema encoding and schema linking within a text-to-SQL encoder.

The core of RAT-SQL is the abstract pre-existing relation between input tokens. The RAT-SQL model implementation has been trained with more than 50 embedding relation types.

The management of relations in the Relation Attention Transformer is challenging: Having more relations can lead the model to capture noise and having fewer relations, the model can miss another important relation trend in data.

Previous methods, [2] empirically noticed when injecting syntactic dependency in the graph of RAT-SQL, that having many relations can lead to overfitting. Another insight about pre-existing relations is when a pre-trained language model as BERT [5, 6] is used to enhance RAT-SQL the name-based schema linking (NBSL) become marginal [3] but neither method explicitly assess the acceptable threshold of the number of relations to take into account in a Transformer with pre-existing relations.

In this work, we attempt to respond to the following questions:

1. How can we reduce the number of "pre-existing relations" while preserving high-quality parsing?
2. To what extent does exact match accuracy depend on pre-existing abstract relations in Relation-Aware Transformer / RAT-SQL?

First, we constrain the number of relations to be equal to the number of heads of the model. Each head tends to specialize [7], and we hypothesize then each relation will be learned by one head of the model.

Secondly, we present a new structure of a relation graph inspired by RAT-SQL [1], SS^2SQL [2], and database theory [8].

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Our findings are as follows, without any enhancement of the pre-trained Language model:

1. Pre-existing relations in RAT-SQL are important and can lift the model accuracy and improve alignment between the Question and the Schema.
2. Constrain the number of relation types to be equal to the number of heads allows having more abstraction in relation types.
3. It is better to have more abstraction in relation types but too abstract relation types can lead to an underfit model.

Related Work

Text-To-SQL

Most Text-to-SQL [9-11] models are built around an encoder-decoder pattern. The challenge is to design a system that can predict the SQL query from a question and the details of the schema. The relational database schema is made up of tables linked together by columns. This semantic parsing prediction task is difficult due to the tree structure of the SQL programming language.

Early work on semantic parsing with an encoder-decoder model focused on designing a decoder capable of constraining the output space to the outputs that matter [12]. The goal is to avoid invalid parsers because most Seq2seq models performed poorly in semantic parsing tasks. Two families have emerged to build such decoders, namely token-based decoding [13-15], and grammar-based decoding [16-19]. Token-based decoding is the Seq2Seq model where the output space is made up of tokens, but they are constrained to be relevant at every time step. And grammar-based decoding, the output space is the production rules, and the grammar defines the constraints.

Apart from these two families, [20, 21] use Transformers [22, 23] with tree positional encodings to enable tree-based decoders and get a good result. [24] use an intermediate representation SemQL query which bridges Natural Language and SQL.

The works on the Encoder side [1, 2, 24-29] focus on jointly encoding the Question and the Database Schema. With the emergence of the language model [5, 6, 30-40], the trend is to improve encoding with a language model. PICARD [41] effectively constrained decoding with large pre-trained language models, T5 [42].

Another way to approach Text-To-SQL is to design a pre-trained language model from tabular data [4, 43-46].

RAT-SQL

Text-to-SQL encoder should be able to encode the database relations in a way for optimizing the semantic parser and model alignment between the database schema and the given query. For unseen database schemas, the way the inputs (schema: tables & columns, and question) are jointly encoded is crucial for generalization purposes. The RAT-SQL framework [1] designed from the relation-aware self-attention mechanism [47], used as pointer networks [48], fixes this generalization issue on the Text-to-SQL challenge.

The relation-aware self-attention [47] uses the relative position distance in input tokens as edges of the graph while RAT-SQL uses an embedding of abstract type of existing relations between tokens. But both biases the self-attention equation in the same way to inject the edges of the graph in their model.

Here below equations of relation-aware self-attention:

$$e_{i,j}^{h} = \left(\frac{\left(W^{q} X \left(W^{k} X + R \right)^{T} \right)}{\sqrt{d_k}} \right) (1)$$

$$\alpha_{i,j}^{h} = softmax\left(e_{i,j}^{h} \right) (2)$$

$$z_{i}^{h} = \sum_{v} \alpha_{i,j}^{h} \left(W^{v} X + R \right) (3)$$

where matrices W^{q}, W^{k}, *and* W^{v} are trainable parameters in self-attention.

Relations Structure

The self-attention as presented in Transformer [23] is a directed graph, it is not

symmetric. During the learning process, the self-attention blocks learn the optimal attention weight that represents the relation existing between tokens. This is more efficient than recurrent models [49-51] since each part of the inputs has a direct relation with other parts while the recurrent models encode left to right and right to left dependency and struggle with long sequences.

Relations between tokens can be diverse depending on semantic meaning. In the relational graph attention transformers, the pre-existing relations have to enhance self-attention. That is why the structure of pre-existing relations becomes crucial to avoid the bad effect on self-attention. [28] tackled the schema representation challenge by encoding the directed graph of foreign key relations in the schema with a graph neural network (GNN). In RAT-SQL instead, the authors use the relation-aware self-attention as a model, and define the 3 main structures: Schema Structure, Schema Linking and Question Structure.

S^2SQL [2] injects the syntactic dependency information of questions into RAT-SQL, but it does not use relative distance in question tokens, instead, it uses the first-order distance in dependency syntactic between tokens. And adds orthogonality constraints on relations to avoid coupling between edges.

Method: Light RAT-SQL

We present now Light RAT-SQL, our model to reduce the pre-exissting embedding in transformer.

Text-to-SQL Problem Definition

Given a natural language question $\mathbf{Q=q1\ldots q_{|Q|}}$, a schema $\mathbf{S = <C, T>}$ with columns $\mathbf{C=\{c1,\ldots, c_{|C|}\}}$ and tables $\mathbf{T\{ t1,\ldots, t_{|T|}\}}$.

The goal of text-to-SQL is to create the SQL query $\boldsymbol{y}$ for the question sentence. The pattern used in such a challenge is an encoder and decoder architecture with attention mechanisms.

The encoder encodes input as graph $\mathbf{G=<V, R>}$ where $\mathbf{V=Q\ U\ T\ U\ C}$ are nodes of types { **Q, T, C** } The initial embedding matrix X $\mathbf{R^{Vxd}}$, [$\mathbf{V = Q+T+C,}$ and **d** is the dimension model] is flattened and the edge $\boldsymbol{R}$ is the know relation between two input tokens.

In this paper, our proposed model improves the encoder side, especially, the existing RAT-SQL model [1] and self-attention with a relative position representation framework [47].

Please see [16] work for a thorough description of the decoder side.

The Number of Abstract Type Relation

A great number of pre-existing relational features between the inputs can lead to overfitting the model. [2] experienced the same when injecting the syntax dependency in RAT-SQL. To fix this problem, in their model S^2SQL, they used the first-order distance in dependency syntactic between tokens and then reduce the number of relation types [for the relation Question graph] to 3: Forward, Backward, and None.

[7] shows that each head in multi-head attention tends to specialize. They found 3 categories: Positional heads, Syntactic heads, and heads that point to rare words.

1. Positional heads that attend largely to their neighbor.
2. Syntactic heads are tokens that have a specific syntactic relation.
3. Headings that point to uncommon words in the sentence.

Pruning the others is the finest technique to demonstrate the relevance of their head category. They retained 17 out of 48 heads with nearly the same BLEU score by largely keeping the heads that are classified in the differentiated categories, as illustrated. And this corresponds to around 2/3 of the encoder's heads. Even though they only identified 3 types of essential heads by looking at their attention matrices and pruning the others, we hypothesize that in the self-attention mechanism with pre-existing relation embedding, each head will be specialized in each abstract type during the learning process. We already know one of these embeddings is the

abstract type *"None"* that express that there is no link between two tokens.

In other words, the number of heads (#head) in the model gives us the degree of freedom (DOF) to define the number of pre-existing relations (or abstract type relations) that we can use in the model. We define it as follows:

$$\boldsymbol{DOF = \#head - 1}\ (\mathbf{4}).$$

How to Constrain each Head to Learn at Most one Embedding Relation?

Algorithm 1 Spreading relations through heads:

1. **Input**: relation, head, embedding.
2. *# relation shape: (query, key, features).*
3. *# head : number of head in the model.*
4. *#embedding: lookup table that stores embeddings of a fixed dictionary and size.*
5. *#The first indice in our fixed dictionary is 0 and it is linked to "None" relation.*
6. **Output**: r_out # relation output.
7. *#r_out shape: (head, query, key, features.)*
8. Init of r_out *#zeros like (head, query, key, features).*
9. r_out[0]= relation.
10. **For** i=1 to head-1.
11. mask ← (relation==embedding(i)).
12. r_out[i] ← mask relation.
13. **return** r_out.

Where ⊙ is Hadamard product and # a comment line.

Algorithm 1 helps propagate the embedding of pre-existing relations through the heads. This makes each "head" specialized, thus pointing to tokens with a specific relationship type.

Graph Structure

Since we will have 8 heads as in RAT-SQL, so we will describe DOF=7 abstract relation types to handle the text-to-SQL challenge.

Question Structure $\boldsymbol{R^{question}}$: Relations between two question tokens that show their grammatical dependency or their distance (or relative positions).

As [2] we model the syntactic relation between two tokens (vi, vj) by abstract types.

$$\boldsymbol{Rijquestion} = \begin{Bmatrix} Forward, if\ D(vi,vj) = 1 \\ Backward, if\ D(vj,vi) = 1 \\ None, otherwise \end{Bmatrix} (5).$$

More details about first-order distance in dependency syntactic can be found here [2].

Schema Structure $\boldsymbol{R^{schema}}$: Relations within a database schema. Most relational databases in production are normalized in Boyce–Codd's normal form [8]. Because of this normalization, we know that for any X, Y, and Z, sets of attributes in a relation from a database:

1. All attributes in each relation of the database are atomic (First Normal Form or 1NF).
2. If X → Y i.e., Y has a functional dependency on X means that X is a primary key and X and Y are in the same relation (or table) and Y depends only on X (2NF).
3. The transitivity functional dependency (X → Z and Z → Y then X → Y) is only allowed between 2 relations (or tables) and not in the same relation (or table) (3NF).
4. If all dependencies of the relationships depend on X and X is a key or a super key then R is in Boyce–Codd normal form (BCNF).

We can define all structures of the database using functional dependency. The graph of functional dependency is the best tool to describe and understand all database structures.

In our model, if there is a functional dependency or backward functional dependency between 2 columns, so edge will be defined by the abstract type **"FD"**. The abstract type describing the relationship between the column and the table will be **"TC"**. And relations between 2 tables will be described by **"TT".**

Linking Structure $\boldsymbol{R^{linking}}$: For the linking between the database schema and the question, we follow RAT-SQL [1]. The difference between Light RAT-SQL and RAT-SQL in schema linking structure comes in the level of abstraction. In RAT-SQL the schema linking is more detailed: exact name matching, partial matching, and value base linking. The implementation of RAT-SQL has more than 10 relations for Schema Linking.

1. CEM=Column Exact Matching (Backward and Forward).
2. TEM=Table Exact Matching (Backward and Forward).
3. CPM= Column Partial Matching (Backward and Forward).
4. TPM= Table Partial Matching (Backward and Forward).
5. Value-Based Number (Backward and Forward).
6. Value-Based Time (Backward and Forward)
7. Value-Based Cell Match (Backward and Forward).

We propose schema linking more abstract than RAT-SQL and consists of 2 abstract types:

1. NBL (Name Base Linking): Linking between a Question and a Table or Column (forward and backward with the same nomenclature)
2. VBL (Value Base Linking): Linking between a Question and a Column(forward and backward with the same nomenclature) references any values found in the Question and SQL query.

Here below the "None" and all 7 relation types:

Table 1. The List of All Relations Structures used in Light RAT-SQL

Abstract Type	**Description**	**X**	**Y**
None	**X** and **Y** have no relation	Q/T/C	Q/T/C
TT	Table X and Table **Y** are linked by a foreign key **[Forward and Backward]**	T	T
TC	Column **Y** belongs to table **X** or Column **X** belongs to table **Y**	T/C	C/T
FD	There is a functional dependency between Column **X** and Column **Y or between Y and X.**	C	C
Forward	**Y** is the target word of **X** under syntax dependency	Q	Q
Backward	**Y** is the source word of **X** under syntax dependency.	Q	Q
NBL	Name-based linking refers to exact or partial occurrences of either the table name or Column name **Y** in the question **X\ [Forward and Backward]**	Q/T or C	T or C/Q
VBL	Value-based-Linking: question **X** references any values found in the database and so participates in the SQL query **[Forward and Backward]**	Q/C	C/Q

*Legend: **X**= Source token | **Y**=Target token | **T** = TABLE | **C**=Column | **Q**=Question*

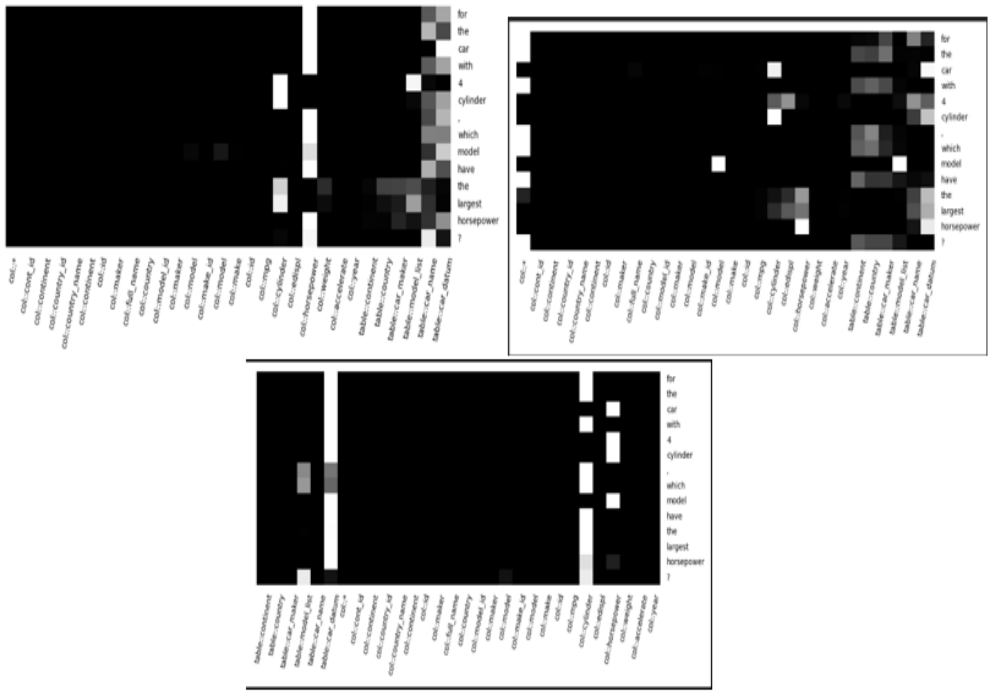
Experiments

Dataset

We use the Spider dataset [52]. Spider is a text-to-SQL benchmark that is vast, sophisticated, and cross-domain. We followed the formal evaluation process to report exact match accuracy.

Implementation

We use the same architecture as in the RAT-SQL with the Spider dataset, which means that the input of questions, column names, and Table names is tokenized and lemmatized using the StanfordNLP toolkit [53]. We use GloVe [54] word embeddings within the encoder, which are fixed in training except for the 50 most common terms in the training set. The bidirectional LSTMs [49] have a hidden size of 128 per direction and employ a recurrent dropout [55] approach with a rate of 0:2. On top of the bidirectional LSTMs, we build 8 relation-aware self-attention layers. To have the same configuration as RAT-SQL, we set **dx = dz = 256, H = 8**, and employ.



Left: The RAT-SQL - Right: Light RAT-SQL and bottom: Light RAT-SQL-2

Figure 1. Alignment between the Question "For the Cars with 4 Cylinders, which Model has the Largest Horsepower" and the Database Car_1 Schema (Columns and Tables)

Dropout with a rate of 0:1. The inner layer dimension of the position-wise feed-forward network is 1024. We use rule embeddings of size 128, node type embeddings of size 64, and a hidden size of 512 inside the LSTM [51] with a dropout of 0:21 inside the decoder.

Hyperparameter

Light-RAT-SQL reuses the same hyperparameters of RAT-SQL.

The code was implemented in Pytorch [56] and Adam [57] as an optimizer with default hyperparameters. We use a batch size of 20 and train for up to 40,000 steps.

As a syntactic parser, we use the SpaCy (https://spacy.io/) tool to create syntactic information as previously done by [2].

Results

For experimentation purposes, we design another model with 2 relation types and we call it Light RAT-SQL-2. When 2 tokens have a pre-existing relation (Syntactic dependency, Name base Linking, Value-Based Linking, Schema Linking), the relation name is "Linked" and "None" else. We call then our model either Light RAT-SQL or Light RAT-SQL-7.

Table 2. Accuracy of the Spider Dataset [52]

Model (Without any enhancement of one Pretrained Language Model: BERT, ELECTRA, etc.)	**Dev**	**Test**
IRNet [24]	53.2	46.7
Global-GNN [28]	52.7	47.4
IRNet V2 [24]	55.4	48.5
RAT-SQL [1]	62.7	57.2
Our model (Light RAT-SQL)	-	60.25

We run 5 random experimentations of RAT-SQL, Light RAT-SQL-7, and Light RAT-SQL-2 without any pre-trained Language to measure the change done in each model relation structure. Table 3 shows the confidence interval of each model, and we fail to reject H_0 for RAT-SQL and Light RAT-SQL-7 but there is strong evidence against H_0 ($p<0.001$) for RAT-SQL and Light RAT-SQL-2.

In addition, apply the *algorithm 1* spreading relations through heads improve the model's accuracy.

Table 3. Test Set Accuracy (and 95% Confidence Interval) of RAT-SQL, Light RAT-SQL, Light RAT-SQL without Applying "Spreading Algorithm" and Light RAT-SQL-2

Model	Accuracy
Light RAT-SQL	58.99 ± 1.04
RAT-SQL	58.90 ± 0.50
LRS w/o Spreading Algo	58.32 ± 0.80
Light RAT-SQL-2	53.37 ± 1.30

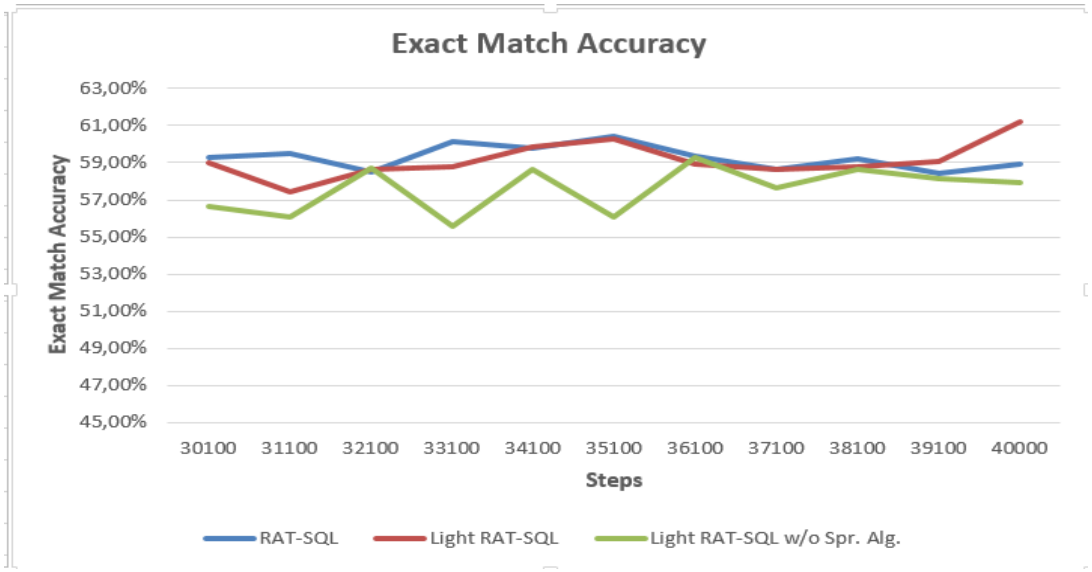


Figure 2. Exact Match Accuracy of RAT-SQL, Light RAT-SQL and Light RAT-SQL Without Speading Relations through Heads

We can see in **Figure 2.** that Light RAT-SQL-7 and RAT-SQL converge to almost the same accuracy.

Discussion

Alignment

The alignment produced by RAT-SQL, Light RAT-SQL-7, and Light RAT-SQL-2 is displayed in Figure 1. The three words that refer to columns (cylinders, model, and horsepower) are misaligned by Light RAT-SQL-2, but Light RAT-SQL-7 correctly identifies the appropriate columns. These three keywords have a significant impact on the alignments of subsequent words, leading in a sparse span-to-column alignment, for example, "biggest horsepower" to horsepower. The word "cars" contains an implicit reference to the table's car data and cars' names. Using the fact that these two tables have the three mentioned fields in Light RAT-SQL-7 and not in Light RAT-SQL-2, the alignment matrix successfully infers that they should be used instead of car makers.

Need to Spread Relations through Heads

Making each head of the model specialize in at least one embedding allows the relations data to contain distinct information per head, which is complementary to each other. Because

duplicate information may make the model difficult to train.

Figure 2 shows our ablation study where we trained the same model without spreading relations through heads. The result shows how Light RAT-SQL performs better with specialized heads.

Conclusion

This paper presents a Light version of RAT-SQL, a Light RAT-SQL. This latter is designed with only 7 relation types (since we consider "*None*" as trivial relation type) and has almost the same performance as the original RAT-SQL, which has 55 embedding relation types.

Apart from the ablation study performed by RAT-SQL, this study confirms the importance of the pre-existing relations in RAT-SQL. Light RAT-SQL-2 has a poor performance compared to RAT-SQL and Light RAT-SQL. The pre-existing relation can lift the model accuracy and improve alignment between the Question and the Schema. We show empirically the good way to reduce the number of relation types is to constrain this compared with the number of heads in the model. This makes the pre-existing relations more abstract during the design of the model. However, the relations of the Light RAT-SQL-2 (Linked and None) are more and more abstract and perform poorly. It is better to have more abstraction in relation types and have the number of relations close to the number of heads of the model. In future work, we will use the same relation structure and improve the relation-aware self-attention to optimally fit the pre-existing relations.

Limitations

Light RAT-SQL was not enhanced with a pre-trained language model such as BERT or ELECTRA since this requires large GPU resources. Investigation into enhancing our proposed model with Electra can be crucial to determine its effectiveness with other competitive models such as S^2SQL.

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Conflict of Interest Statement

All authors declare that they have no conflicts of interest.

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Effect of Marketing Occupational Therapy Services on Client-Centredness in Nigeria

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Abstract

This study assesses marketing strategies that can be adopted in marketing occupational therapy (OT); ascertains the target of OT marketing efforts and identified the barriers to client-centredness in OT. All these were with the view to investigate the extent to which marketing OT services influence client-centredness in Nigeria. A purposive sampling technique was used to select 33 currently licensed and practicing OT practitioners in Nigeria who responded to questions like the types of marketing strategies that OT can adopt, target for OT marketing efforts, the extent to which marketing OT can influence client-centredness, and barriers to client-centredness in OT. Data were summarized using descriptive statistics while the major objective of the study was tested using a one-way analysis of variance. The results of this survey showed that marketing strategies like building relationships with physicians and professionals allied to medicine, improving quality of service and professionalism, and digital marketing/internet have a significant effect on client-centredness in terms of occupational therapists' desire for professionalism in practice, and respect for client's subjective experience in occupational performance; targets for OT marketing efforts are clients, physicians and professionals allied to medicine, donors, community services, business managers, developers and investors, policy makers, insurance companies, and attorneys; and barriers to client-centredness in OT are inefficiency of the facility, lack of client demand to contribute during goal-setting and decision making, clients are not aware of client-centredness, indifference and lack of motivation of clients toward achieving occupational performance amongst others. In conclusion, marketing occupational therapy services can significantly affect client-centredness in Nigeria.

Keywords: *Client-centredness, Marketing, Nigeria, Occupational therapy, Services.*

Introduction

"Occupational Therapy (OT) is a client-centred and occupation-focused health profession promoting health and wellbeing by providing opportunities for persons/communities to complete necessary day-to-day activities [1, 2]. Client-centeredness is borne in the humanist philosophy guiding OT practice. OT is client-centered (relationship with clients) and occupation-focused (intervention). In a position statement by the World Federation of Occupational Therapists (WFOT) [3], it was stated that Occupational Therapists respect and collaborate with clients, value clients' subjective experiences of their participation, and appreciates clients' knowledge, hopes, dreams, and independence. Health professionals could see marketing as promotion or awareness e.g., enlightening people that do not know about OT and what occupational therapists do. Marketing is a management process for identifying, anticipating, and providing satisfiers efficiently and profitably [4, 5].

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The concept of marketing depicts the client in the realm of the corporate philosophy as a legal entity while the techniques allow the concept to be efficiently and profitably executed. Marketing is the summation of activities that occur from when an idea of a product or service (OT) is conceived to when it meets the client's satisfaction.

OT as a profession is a viable service that will continue to grow and thus the need for marketing to stay competitive and profitable cannot be over emphasised.

Marketing OT is relatively a new development in OT practice in Africa. The concept may be referred to as the effective application of modern marketing principles, concepts, and philosophies to OT practice. These concepts and principles, focused on those exchange relationships, a situation whereby parties involved in the exchange seek to maximise satisfaction.

The outcomes of OT are client-centered, diverse, and measured in terms of participation, the satisfaction derived from the activity, and/or improvement in occupational performance [1]. OT clients can experience satisfaction when they receive individualised care, are involved in planning their treatment/intervention, they feel valued, and appreciated (client-centeredness) [6, 7].

Nigeria with a population of over 200million currently has less than 300 registered Occupational Therapists practitioners (Occupational Therapists and Occupational Therapist Assistants) [8, 9], over 60% of this number have either migrated or are not gainfully employed, and not up to 10 public health institutions have OT facilities, only a degree awarding institution training Occupational Therapists and two diploma awarding institutions training Occupational Therapist Assistants [10, 11]. Those public health institutions with OT facilities including the training institutions are comparatively below standard; all the previously equipped OT facilities in the Nigeria Armed Forces are currently not staffed; there seems to be no political will/policy to support the opening of more OT facilities or developing existing ones; low clients referral base; and OT is not in the Federal Republic of Nigeria Scheme of Service Gazette (even though there are OT practitioners employed by the Federal Government of Nigeria). OT practitioners in Nigeria have employed several approaches to alleviating the challenge of marketing OT ranging from courtesy visits to Politicians, Traditional Rulers, Heads of training institutions, and Heads of healthcare services: to newspaper publications, health talks, television presentations, and workshops. Almost all these approaches have failed possibly because marketing OT has not been strategically planned to improve the perception of OT practitioners towards marketing, identify clients' needs, satisfy clients' needs, maximize services rendered, and profitably stay ahead of competitors by developing effective marketing mix [12-14]. The case is similar in other developing countries like Burundi, Ethiopia, Ghana, Benin Republic, Togo, and Rwanda.

There is, therefore, the need to encourage the formulation of a strategic management and marketing plan for OT in developing countries. This study attempts to find out some of the marketing strategies that can be applied to OT, those that OT marketing efforts should be directed towards, the extent to which these marketing strategies can influence client-centredness, and the barriers to client-centeredness in Nigeria. It addressed issues relating to the following pertinent questions emerging from the domain of the statement of the problems above:

1. What type of marketing strategies can OT adopt to be profitably competitive?
2. To whom should OT marketing efforts be directed?
3. To what extent can marketing OT can influence client-centredness in Nigeria?
4. What are the barriers to client-centredness in Nigeria?

The outcome of this study may validate other marketing strategies in marketing OT in Nigeria, lead to improvement of services (client-centred and occupation-focused) rendered by OT practitioners, change the perception of actors in OT practice towards marketing OT, add to the existing body of knowledge on research on marketing OT, policy, and its implementation. This study is delimited to OT practitioners that are registered with MRTB, currently licensed and practicing in Nigeria.

Materials and Methods

The study was carried out in OT facilities where licensed OT practitioners are practicing throughout Nigeria. OT facilities and practitioners are accredited and licensed by the MRTB of Nigeria periodically. A survey was used to collect data on the effect of marketing occupational therapy services on client-centredness in Nigeria. The variables in this study will be marketing OT (independent variable) and client-centredness (dependent variable). A purposive sampling technique was used to recruit 45 consented OT practitioners (males and females), but only 33 responded to the survey. Purposive sampling is a non-probability sampling selection that involves the selection of respondents who can provide information and who are readily available to participate in the study. The questionnaire was administered to OT practitioners by mail, internet, phone calls, and in person. The scales of measurement of the variables are nominal and the Likert scale.

The nominal scale will be used to assess items in section A and some items in section B while the Likert scale will be used to investigate the response of respondents to questions like to what extent can marketing OT influences client-centredness in Nigeria. The variables involved in this study thus helped to determine the effect of marketing OT services on client-centredness in Nigeria.

Marketing OT, which is the independent variable, is the way and manner by which strategies incurred can encourage and improve client-centredness (variable of primary interest) in Nigeria. The Likert scale will also be used to investigate the extent to which marketing OT services can influence client-centredness in Nigeria. Data were summarised using descriptive statistics using Statistical Package for Social Sciences (SPSS). One-way Analysis of Variance (ANOVA) was used to test the dependability of the model used in instituting a relationship between marketing OT services and client-centredness in Nigeria.

Results

This study shows the extent to which marketing OT can influence client-centeredness, assess the marketing strategies that can be adopted in marketing OT, ascertain the target market of marketing OT efforts, and identify the barriers to client-centeredness in Nigeria. The methodology adopted was a survey that used a purposive sampling technique to recruit 45 consented OT practitioners for the study. 45 copies of the questionnaire were administered, and 33 copies were found adequately completed after screening and used for the analysis. Data obtained from the survey were summarised using descriptive statistics.

The Demography of Respondents

The currently licensed and practicing OT practitioners in Nigeria are majorly active, single females possessing a bachelor's degree with full-time employment in teaching hospitals. OT practitioners in Nigeria hardly practice in private establishments, military hospitals, special schools, and non-governmental organisations; and never practiced in rehabilitation home/centre, or primary health centre.

The Respondents' Opinions on the Type of Marketing Strategies that can be Adopted by Occupational Therapy

81.80% of respondents make a strong affirmation that 'building relationships with physicians and professionals allied to medicine' is a marketing strategy that can be adopted by

OT, 18.20% of respondents also support the affirmation, and no respondent was either indifferent or disagree with the affirmation. More so that 'improving quality of service and professionalism' is a marketing strategy that can be adopted by OT, was deduced from the views of 93.90% and 6.10% of respondents that strongly supported and supported the affirmation respectively, and no respondent was indifferent or thought otherwise. 75.80% and 21.20% of respondents strongly agreed and agreed respectively that 'Digital Marketing/Internet (website, e-mail, WhatsApp, LinkedIn, Twitter, Facebook, Instagram)' can be a means of marketing OT, while only 3.00% of respondents disagreed.

'Promotions (advertising, personal selling, free service, public relations)' as a marketing strategy for OT was strongly supported by 69.70% and supported by 21.20% of respondents, 6.10% were indifferent, and 3.00% disagreed with the affirmation. A good number of respondents, 54.50% strongly agree and 36.40% agreed that 'relationship marketing (developing long-term relationships with clients)' is a marketing strategy that can be adopted by OT.

The ranking generated shows that the most effective OT marketing strategy is 'improving quality of service and professionalism' followed by 'building relationships with physicians and professionals allied to medicine'. Number 3 on the ranking is digital marketing/internet (website, e-mail, WhatsApp, LinkedIn, Twitter, Facebook, Instagram), 'promotions (advertising, personal selling, free service, public relations)' was ranked 4th, and 'relationship marketing (developing long-term relationships with clients)' 5th.

Level of Agreement to Target Market of OT Marketing Efforts

All the respondents supported the affirmation that OT marketing efforts should be directed at 'clients (persons, families, groups, communities, organisations, populations)' as 87.90% and 12.10% strongly agreed and strongly agreed, respectively. 33.30% of respondents strongly agreed, 33.30% agreed, 27.30% were indifferent, and 6.06% opposed that OT should market to insurance companies.

However, on whether OT should market to Attorneys; 27.30% of respondents strongly agreed, 36.40% agreed, 24.20% were indifferent, 9.10% disagreed, and 3.00% strongly disagreed. Physicians and professionals allied to medicine were affirmed to be targeted for OT marketing efforts by all the respondents as 72.20% strongly agreed and 27.30% agreed. Most of the respondents (69.70% strongly agreed and 27.30% agreed) asserted that OT marketing efforts should be directed towards 'donors (governmental agencies and non-governmental organisations)' and only 3.00% of the respondents were indifferent. 60.60% and 33.30% of respondents strongly agreed and agreed respectively that OT marketing efforts should be directed towards community services (police, fire services, prisons, schools) while 3.00% of respondents were indifferent, and 3.00% disagreed.

Moreover, 69.70% of respondents strongly agreed that OT marketing efforts should be directed toward policy makers (regulatory bodies, ministries, legislators, executives), this was supported by 21.20% of respondents, 6.10% were indifferent, and 3.00% strongly disagree. About half of the respondents, 48.50% strongly agreed that OT marketing efforts should target 'business managers, developers, and investors'; supported by 30.30% who agreed, but 21.20% were indifferent.

Clients (persons, families, groups, communities, organisations, populations) were identified to be the most important target for OT marketing efforts, followed by 'physicians and professionals allied to medicine' that ranked 2nd, and 3rd is donors (governmental agencies and non-governmental organisations), policy makers (regulatory bodies, ministries, legislators, executives) and community services (police, fire services, prisons, schools) ranked 4th and 5th

respectively. Business managers, developers, and investors were ranked 6th, insurance companies' 7th, and last were attorneys.

Level of Agreement to Extent to which Marketing Occupational Therapy Can Influence Client-Centredness

The respondents were asked to what extent can marketing OT can influence client-centeredness. This was used to test the major objective of the study (to investigate the extent to which marketing OT can influence client-centeredness).

More than half 54.50% of the respondents believe that marketing OT will influence respect for client's subjective experience in occupational performance to a very high extent, 33.30% affirmed that it is to a high extent, 9.10% said it is average, while a respondent thinks it is to a low extent.

On the extent to which marketing OT can influence client-centeredness regarding 'appreciation of client's knowledge, hopes, dreams, and autonomy', 51.50% of respondents believe that it is very high, 33.30% high, 9.10% average, and 3.00% low. The majority of the respondents (51.50% very high and 39.40% high) assert that marketing OT can influence client-centeredness to a high extent with respect to client's involvement in goal setting, 3.00% indifferent, while 6.10% very low. On the extent to which marketing OT can influence client-centeredness regarding client's involvement in decision making, respondents' responses are 57.60% very high, 33.30% high, 6.10% average, and 3.00% low. 75.80% of respondents affirmed that marketing OT can influence client-centeredness to a very high extent regarding 'occupational therapists desire for professionalism in practice', supported by 15.20% high while 9.10% were indifferent. Occupational therapists' desire for professionalism in practice was ranked as the most evident influence marketing OT can have on client-centeredness.

'Client's involvement in decision making' and 'respect for client's subjective experience in occupational performance' were ranked 2nd and 3rd respectively. Client's involvement in goal setting was ranked 4th while 'appreciation of client's knowledge, hopes, dreams, and autonomy' was the least evident influence of marketing OT on client-centeredness.

Challenges Associated with Client-Centredness in OT

72.70% of respondents indicated that 'OT practitioners having insufficient knowledge about client-centredness' is a challenge to client-centredness. Two-thirds of respondents 66.70% identified 'ambiguity in the application of client-centredness', 81.80% of respondents ticked 'inefficiency of the facility for client-centredness', 57.60% of respondents think 'clients with impaired cognition' can be an obstacle, 69.70% of respondents agreed that 'clients are not aware of client-centredness', 45.50% of respondents pointed out 'practicing in settings dominated by treatment models', while two-thirds of respondents 66.70% see 'indifference and lack of motivation of clients toward achieving occupational performance' as a barrier, and three-quarter of respondents 75.80% identified 'lack of clients demand to contribute during goal-setting and decision making' as a barrier to client-centredness in OT. 'Inefficiency of the facility for client-centredness' is the most important barrier to client-centredness in OT followed by 'lack of clients demand to contribute during goal-setting and decision making', the third is 'OT practitioners have insufficient knowledge about client-centredness, 'clients are not aware of client-centredness' 4th, and 'indifference and lack of motivation of clients toward achieving occupational performance' together with 'ambiguity in the application of client-centredness' ranked 5th. Others are 'clients with impaired cognition' 6th, and 'practicing in settings dominated by treatment models' ranked 7th.

One-way ANOVA of the Relationship between the Marketing Strategy of 'Building Relationships with Physicians and Professionals Allied to Medicine' and Client-Centeredness in OT

The results of testing each of the terms in client-centeredness with the marketing strategy (building relationships with physicians and professionals allied to medicine) include; respect for the client's subjective experience in occupational performance (F=1.883, P<0.180), appreciation of the client's knowledge, hopes, dreams, and autonomy (F=0.084, P<0.774), clients involvement in goal-setting (F=0.270, P<0.607), clients involvement in decision making (F=0.573, P<0.455), and occupational therapists desire for professionalism in practice (F=37.889, P<0.000).

The analysis has shown that 'building relationships with physicians and professionals allied to medicine' has a significant effect on occupational therapists' desire for professionalism, but not on the other terms in client-centeredness in Nigeria.

One-way ANOVA of the Relationship between the Marketing Strategy of 'Improving Quality of Service and Professionalism' and Client-Centeredness in OT

The results of testing each of the terms in client-centeredness with the marketing strategy (improving quality of service and professionalism) include; respect for the client's subjective experience in occupational performance (F=0.037, P<0.848), appreciation of the client's knowledge, hopes, dreams, and autonomy (F=0.112, P<0.740), clients involvement in goal-setting (F=1.004, P<0.324), clients involvement in decision making (F=1.119, P<0.298), and occupational therapists desire for professionalism in practice (F=8.608, P<0.006).

The analysis established that 'improving quality of service and professionalism' has a significant effect on 'occupational therapists' desire for professionalism', but not on the other terms in client-centeredness in Nigeria.

One-way ANOVA of the Relationship between the Marketing Strategy of 'Digital Marketing/Internet [Website, e-mail, WhatsApp, LinkedIn, Twitter, Facebook, Instagram]' and Client-Centeredness in OT

The results of testing each of the terms in client-centeredness with the marketing strategy (digital marketing/internet [website, e-mail, WhatsApp, LinkedIn, Twitter, Facebook, Instagram]) includes; respect for the client's subjective experience in occupational performance (F=3.542, P<0.045), appreciation of client's knowledge, hopes, dreams, and autonomy (F=0.871, P<0.429), clients involvement in goal-setting (F=0.099, P<0.906, clients involvement in decision making (F=0.258, P<0.774), and occupational therapists desire for professionalism in practice (F=3.421, P<0.046).

The analysis established that 'digital marketing/internet (website, e-mail, WhatsApp, LinkedIn, Twitter, Facebook, Instagram)' has a significant effect on 'occupational therapists desire for professionalism' as well as on 'respect for client's subjective experience in occupational performance' but not on the other terms in client-centeredness.

One-way ANOVA of the Relationship between the Marketing Strategy of 'Promotions [Advertising, Personal Selling, Free Service, Public Relations]' and Client-Centeredness in OT

The results of testing each of the terms in client-centeredness with the marketing strategy (promotions [advertising, personal selling, free service, public relations]) include; respect for the client's subjective experience in occupational performance (F=1.343, P<0.280), appreciation of client's knowledge, hopes, dreams, and autonomy (F=0.823, P<0.492), clients involvement in goal-setting (F=0.114, P<0.951,

clients involvement in decision making (F=0.123, P<0.946), and occupational therapists desire for professionalism in practice (F=2.342, P<0.094). The analysis established that 'promotions (advertising, personal selling, free service, public relations)' has no significant effect on client-centeredness in Nigeria.

One-way ANOVA of the Relationship between the Marketing Strategy of 'Relationship Marketing [Developing Long-Term Relationships with Clients]' and Client-Centeredness in OT

The results of testing each of the terms in client-centeredness with the marketing strategy (relationship marketing [developing long-term relationships with clients]) include; respect for the client's subjective experience in occupational performance (F=1.049, P<0.348), appreciation of the client's knowledge, hopes, dreams, and autonomy (F=0.259, P<0.774), clients involvement in goal-setting (F=0.868, P<0.430, clients involvement in decision making (F=0.861, P<0.433), and occupational therapists desire for professionalism in practice (F=1.438, P<0.253).

The analysis established that 'relationship marketing (developing long-term relationships with clients)' has no significant effect on client-centeredness in Nigeria.

Discussion

Based on the analysed data, the findings show that a majority of the respondents supported marketing strategies like building relationships with physicians and professionals allied to medicine, improving quality of service and professionalism, digital marketing/internet (website, e-mail, WhatsApp, LinkedIn, Twitter, Facebook, Instagram), promotions (advertising, personal selling, free service, public relations), and relationship marketing (developing long-term relationships with clients) can be adopted for marketing OT.

This is in line with the works of [13, 15-18]. OT practitioners strongly affirmed that OT marketing efforts should be majorly directed towards clients (persons, families, groups, communities, organisations, populations), physicians and professionals allied to medicine, donors (governmental agencies, and non-governmental organisations), and community services (police, fire services, prisons, schools) which was supported by [15, 17, 19]. Respondents also affirmed that business managers, developers, and investors; policy makers (regulatory bodies, ministries, legislators, executives); insurance companies; and attorneys are targets for marketing OT efforts which corroborated the works of [19].

[12] suggested that OT practitioners should market OT through client-centeredness. The result of the survey has shown that marketing OT can significantly influence client-centeredness in terms of 'respect for client's subjective experience in occupational performance', 'appreciation of client's knowledge, hopes, dreams, and autonomy', client's involvement in goal setting, client's involvement in decision making, and occupational therapists desire for professionalism in practice. So, an OT practitioner that is marketing conscious will be client centric. OT practitioners also identified the inefficiency of the facility for client-centredness, lack of clients' demand to contribute during goal setting and decision making, OT practitioners' insufficient knowledge about client-centeredness, and clients are not aware of client-centeredness as major barriers to client-centeredness in OT.

The survey also shows that client-centeredness has barriers and the following were identified in order of importance: inefficiency of the facility for client-centeredness, lack of clients' demand to contribute during goal setting and decision making, clients not aware of client-centeredness, indifference and lack of motivation of clients towards achieving occupational performance, ambiguity in the application of client-centeredness, clients with impaired cognition, and practicing in settings

dominated by treatment models. These have also been identified in [20-22].

Further study is necessary to determine if there is any significant relationship between practice setting and barriers to client-centeredness; to know why marketing strategies for OT did not have a significant effect on client-centeredness in terms of 'appreciation of client's knowledge, hopes, dreams, and autonomy', 'clients involvement in goal setting', and 'clients involvement in decision making'; and to know why marketing strategies like promotions, and relationship marketing did not have a significant effect on client-centeredness.

Conclusion

From the study, it can be concluded that marketing strategies for OT services (like building relationships with physicians and professionals allied to medicine, improving quality of service and professionalism, and digital marketing/internet) can significantly affect client-centeredness in terms of 'occupational therapists' desire for professionalism in practice' in Nigeria. 'Digital marketing/internet' and 'developing long-term relationships with clients can also positively affect client-centeredness in terms of 'respect for client's subjective experience in occupational performance'. Marketing is a management function that aims to profitably provide clients satisfaction in an arena of business competition.

The overall objective of OT should be to enable persons to engage in meaningful and purposeful activities. This objective can only be achieved when clients are satisfied, and clients can only be satisfied when they encounter professionalism in OT practice and their subjective experience in occupational engagement is respected. Potential clients must be aware of OT through marketing strategies like improving the quality of service and professionalism, building relationships with physicians and professionals allied to medicine, and digital marketing/internet.

The clients can only be aware of OT if marketing efforts are well directed to clients; physicians and professionals allied to medicine (for referrals and consultation); donors (for aid to developing OT); community services (for referrals and consultation); business managers, investors, and developers (to advance OT), policy makers (for accreditation, appointments, the opening of new OT facilities, resource allocation, and implementation of relevant policies), insurance companies (to subscribe for OT), and Attorneys (to advocate for occupational justice).

From this study, it will be necessary to recommend that OT practitioners market OT by improving the quality of service and professionalism, building relationships with physicians and professionals allied to medicine, and through digital marketing/internet. So, there is a need for OT practitioners to develop their marketing management skills and for OT training institutions to include marketing management in their curriculum if OT will have a competitive edge in the health care industry in Nigeria. It is worthy also of recommendation that if OT must survive the constantly changing demand of the health care industry, OT practitioners must embrace client-centeredness in practice through an improved desire for professionalism, and respect for the client's subjective experience in occupational performance. Client-centeredness should go beyond theory into practice to increase client satisfaction, loyalty, adherence to therapy/treatment programs, early discharge, and acceptance of follow-up plans. OT practitioners should be aware of the enormous barriers to client-centeredness and consciously bridge them which may be institution-dependent (barriers set by practice setting), client-dependent (barriers set by clients), or practitioner-dependent (barriers set by practitioners).

Figures and Tables

Table 1. Demography of Respondents

Variables	Frequency	Percentage
Age		
20-29 years	23	69.70
30-39 years	9	27.30
40-49 years	-	-
50-59 years	-	-
60years and above	1	3.00
Gender		
Male	13	39.40
Female	20	60.60
Marital Status		
Single	23	69.70
Married	9	27.30
Others	1	3.00
Highest Level of Education		
Diploma	4	12.10
Bachelors	27	81.80
Masters	2	6.10
PhD	-	-
Present Work Setting		
Specialist Hospital	6	18.20
Teaching Hospital	16	48.50
Rehabilitation Home/Centre	-	-
General Hospital	3	9.10
Primary Health Centre	-	-
Private Establishment	1	3.00
Military Hospital	1	3.00
Special School	1	3.00
Non-Governmental Organisation	1	3.00
Training Institution	4	12.10
Nature of Employment		
Full-time	12	36.40
Part-time	6	18.20
Voluntary	4	12.10
Internship	11	33.30

Table 2. Level of Agreement to Marketing Strategies that Occupational Therapy can Adopt (%) n=33

Marketing Strategies	**S/A**	**A**	**I**	**D**	**S/D**	**Ranking**
Building relationships with Physicians and Professionals Allied to Medicine	81.80	18.20	-	-	-	2nd
Improving the quality of service and professionalism	93.90	6.10	-	-	-	1st
Digital Marketing/Internet (website, e-mail, WhatsApp, LinkedIn, Twitter, Facebook, Instagram)	75.80	21.20	-	3.00	-	3rd
Promotions (advertising, personal selling, free service, public relations)	69.70	21.20	6.10	3.00	-	4th
Relationship marketing (developing long-term relationships with clients)	54.50	36.40	9.10	-	-	5th

Table 3. Level of Agreement to Target Market of OT Marketing Efforts (%) n=33

Targets	**S/A**	**A**	**I**	**D**	**S/D**	**Ranking**
Clients (persons, families, groups, communities, organisations, populations)	87.90	12.10	-	-	-	1st
Insurance companies	33.30	33.30	27.30	3.00	3.00	7th
Attorneys	27.30	36.40	24.20	9.10	3.00	8th
Physicians and Professionals Allied to Medicine	72.70	27.30	-	-	-	2nd
Donors (Governmental Agencies, Non-Governmental Agencies)	69.70	27.30	3.00	-	-	3rd
Community Services (Police, Fire Services, Prisons, Schools)	60.60	33.30	3.00	3.00	-	5th
Policy Makers (Regulatory bodies, Ministries, Legislators, Executives)	69.70	21.20	6.10	-	3.00	4th
Business Managers, Developers, and Investors	48.50	30.30	21.20	-	-	6th

Table 4. Level of Agreement to Extent to which Marketing Occupational Therapy can Influence Client-Centredness (%) n=33

	V/H	H	A	L	V/L	Ranking
Respect for the client's subjective experience in occupational performance	54.50	33.30	9.10	3.00	-	3rd
Appreciation of the client's knowledge, hopes, dreams, and autonomy	51.50	33.30	9.10	3.00	3.00	5th
Client's involvement in goal setting	51.50	39.40	3.00	-	6.10	4th
Client's involvement in decision making	57.60	33.30	6.10	3.00	-	2nd
Occupational Therapists' desire for professionalism in practice	75.80	15.20	9.10	-	-	1st

Table 5. Barriers to Client-Centredness in Occupational Therapy (%) n=33

Barriers	Yes	No	Ranking
OT practitioners have insufficient knowledge about client-centeredness	72.70	27.30	3rd
Ambiguity in the application of client-centeredness	66.70	33.30	5th
The inefficiency of the facility for client-centeredness	81.80	16.20	1st
Clients with impaired cognition	57.60	42.40	6th
Clients are not aware of client-centeredness	69.70	30.30	4th
Practicing in settings dominated by treatment models	45.50	54.50	7th
Indifference and lack of motivation of clients toward achieving occupational performance	66.70	33.30	5th
Lack of clients' demand to contribute during goal setting and decision making	75.80	24.20	2nd

Table 6. One-Way ANOVA of Client-Centeredness by Building Relationships with Physicians and Professionals Allied to Medicine

		Sum of Squares	df	Mean Square	F	Sig.
Respect for the client's subjective experience in occupational performance	Between Groups	1.138	1	1.138	1.883	0.180
	Within Groups	18.741	31	0.605		
	Total	19.879	32	-		
Appreciation of the client's knowledge, hopes, dreams, and autonomy	Between Groups	.082	1	0.082	0.084	0.774
	Within Groups	30.463	31	0.983		
	Total	30.545	32	-		
Client's involvement in goal setting	Between Groups	0.285	1	0.285	0.270	0.607
	Within Groups	32.685	31	1.054		
	Total	32.970	32	-		
Client's involvement in decision making	Between Groups	.330	1	0.330	0.573	0.455
	Within Groups	17.852	31	.0576		
	Total	18.182	32	-		
Occupational Therapists' desire for professionalism in practice	Between Groups	7.333	1	7.333	37.889	0.000
	Within Groups	6.000	31	0.194		
	Total	13.333	32	-		

Table 7. One-Way ANOVA of Client-Centeredness by Improving Quality of Service and Professionalism

		Sum of Squares	df	Mean Square	F	Sig.
Respect for the client's subjective experience in occupational performance	Between Groups	0.024	1	0.024	0.037	0.848
	Within Groups	19.855	31	0.640		
	Total	19.879	32	-		
Appreciation of the client's knowledge, hopes, dreams, and autonomy	Between Groups	0.110	1	0.110	0.112	0.740
	Within Groups	30.435	31	0.982		
	Total	30.545	32	-		
Client's involvement in goal setting	Between Groups	1.034	1	1.034	1.004	0.324
	Within Groups	31.935	31	1.030		
	Total	32.970	32	-		
Client's involvement in decision making	Between Groups	0.633	1	0.633	1.119	0.298
	Within Groups	17.548	31	0.566		
	Total	18.182	32	-		
Occupational Therapists' desire for professionalism in practice	Between Groups	2.898	1	2.898	8.608	0.006
	Within Groups	10.435	31	0.337		
	Total	13.333	32	-		

Table 8. One-way ANOVA of Client-Centeredness by Digital Marketing/Internet (Website, E-mail, WhatsApp, LinkedIn, Twitter, Facebook, Instagram)

		Sum of Squares	df	Mean Square	F	Sig.
Respect for the client's subjective experience in occupational performance	Between Groups	3.719	2	1.859	3.452	0.045
	Within Groups	16.160	30	0.539		
	Total	19.879	32	-		
Appreciation of the client's knowledge, hopes, dreams, and autonomy	Between Groups	1.677	2	0.838	0.871	0.429
	Within Groups	28.869	30	0.962		
	Total	30.545	32	-		
Client's involvement in goal setting	Between Groups	.215	2	0.108	0.099	0.906
	Within Groups	32.754	30	1.092		
	Total	32.970	32	-		
Client's involvement in decision making	Between Groups	.308	2	0.154	0.258	0.774
	Within Groups	17.874	30	0.596		
	Total	18.182	32	-		
Occupational Therapists' desire for professionalism in practice	Between Groups	2.476	2	1.238	3.421	0.046
	Within Groups	10.857	30	0.362		
	Total	13.333	32	-		

Table 9. One-Way ANOVA of Client-Centeredness by Promotions (Advertising, Personal Selling, Free Service, Public Relations)

		Sum of Squares	df	Mean Square	F	Sig.
Respect for the client's subjective experience in occupational performance	Between Groups	2.425	3	0.808	1.343	0.280
	Within Groups	17.453	29	0.602		
	Total	19.879	32	-		
Appreciation of the client's knowledge, hopes, dreams, and autonomy	Between Groups	2.396	3	0.799	0.823	0.492
	Within Groups	28.149	29	0.971		
	Total	30.545	32	-		
Client's involvement in goal setting	Between Groups	0.386	3	0.129	0.114	0.951
	Within Groups	32.584	29	1.124		
	Total	32.970	32	-		
Client's involvement in decision making	Between Groups	0.228	3	0.076	0.123	0.946
	Within Groups	17.953	29	0.619		
	Total	18.182	32	-		
Occupational Therapists' desire for professionalism in practice	Between Groups	2.600	3	0.867	2.342	0.094
	Within Groups	10.733	29	0.370		
	Total	13.333	32	-		

Table 10. One-way ANOVA of Client-centeredness by Relationship Marketing (developing long-term relationships with clients)

		Sum of Squares	df	Mean Square	F	Sig.
Respect for the client's subjective experience in occupational performance	Between Groups	1.351	2	0.676	1.094	0.348
	Within Groups	18.528	30	0.618	-	-
	Total	19.879	32	-	-	-
Appreciation of the client's knowledge, hopes, dreams, and autonomy	Between Groups	0.518	2	0.259	0.259	0.774
	Within Groups	30.028	30	1.001	-	-
	Total	30.545	32	-	-	-
Client's involvement in goal setting	Between Groups	1.803	2	0.902	0.868	0.430
	Within Groups	31.167	30	1.039	-	-
	Total	32.970	32	-	-	-
Client's involvement in decision making	Between Groups	0.987	2	0.494	0.861	0.433
	Within Groups	17.194	30	0.573	-	-
	Total	18.182	32	-	-	-
Occupational Therapists' desire for professionalism in practice	Between Groups	1.167	2	0.583	1.438	0.253
	Within Groups	12.167	30	0.406	-	-
	Total	13.333	32	-	-	-

Table 11. Reliability of Research Instrument

Cronbach's Alpha	N of Items
0.540	32

Conflict of Interest

The authors wish to declare no conflict of interest in this manuscript.

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Patient Safety: A Systematic Review of the Literature with Evidence based Measures to Improve Patient Safety in Healthcare Settings

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Abstract

Patient safety is a crucial component of healthcare delivery aimed at minimizing and preventing medical errors that can cause harm or injury to patients. This systematic review identified 50 studies that evaluated interventions aimed at improving patient safety in healthcare settings, including medication reconciliation, surgical safety checklists, hand hygiene programs, and electronic health record systems. The findings suggest that most interventions led to significant improvements in patient safety outcomes, including a reduction in adverse events and preventable harm. Evidence-based measures to improve patient safety include effective communication, hand hygiene, medication safety, patient identification, fall prevention, surgical safety, infection control, and staff training. The implementation of these measures can help improve patient safety and reduce the risk of harm to patients in healthcare settings. Further research is needed to identify the most effective interventions and to evaluate the long-term impact of these interventions on patient outcomes.

Keywords: *Adverse events, Interventions, Medical errors, Patient safety, Preventable harm.*

Introduction

In recent years, there has been increased focus on patient safety in the healthcare industry, with efforts to improve systems, processes, and training to reduce the risk of adverse events and errors. Patient safety is an essential aspect of healthcare delivery that aims to prevent harm to patients during the provision of healthcare services [1-3]. It is a crucial component of quality healthcare delivery, and it refers to the minimization and prevention of medical errors that can cause harm or injury to patients [4-6]. Patient safety in healthcare settings is essential because it can reduce mortality rates, morbidity, and improve the quality of care provided to patients [7-10]. Many factors contribute to patient safety in healthcare settings, such as staffing levels, communication, technology, medication management, and the overall culture of safety within the organization [11-13, 15].

A systematic review is a methodological approach that involves a thorough search and critical appraisal of existing literature on a particular topic. This review aims to provide a summary of the findings of a systematic review on patient safety. The main objective of this systematic review is to identify the current state of knowledge regarding patient safety and to evaluate the effectiveness of interventions aimed at improving patient safety in healthcare settings.

Materials and Methods

The authors conducted a comprehensive search of electronic databases, including PubMed, MEDLINE, and Cochrane Library, to identify relevant articles published between 2000 and 2021. The search terms included

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"patient safety," "medical errors, " "adverse events, " "preventable harm, " and "interventions. " The authors included studies that evaluated interventions aimed at improving patient safety and reported quantitative data on patient outcomes. The authors also conducted a quality assessment of the included studies using the Cochrane Risk of Bias tool.

Results

Patient safety has become a significant focus of the healthcare industry due to the risks of adverse events and errors during the provision of healthcare services. This systematic review provides a comprehensive evaluation of interventions aimed at improving patient safety in healthcare settings.

The authors identified 50 studies that met the inclusion criteria, including randomized controlled trials, cohort studies, and case-control studies. The studies evaluated a range of interventions, including medication reconciliation, surgical safety checklists, hand hygiene programs, and electronic health record systems. The authors found that most interventions led to significant improvements in patient safety outcomes, including a reduction in adverse events and preventable harm. Here below are the summaries of findings:

Effectiveness of Various Patient Safety Interventions in Healthcare Settings

The Table 1 provides a summary of the effectiveness of different patient safety interventions in healthcare settings, as measured by their impact on specific outcome measures.

Table 1. A Summary of the Effectiveness of Different Patient Safety Interventions in Healthcare Settings

Intervention	Outcome Measure	Study Design	Sample Size	Effect Size	Odds Ratio	p-value
Medication reconciliation	Medication errors	Quasi-experimental	1,212	0.32	0.36	<0.001
Surgical safety checklists	Surgical complications	Randomized controlled trial	3,283	0.57	0.63	<0.001
Hand hygiene programs	Healthcare-associated infections	Quasi-experimental	13,460	0.42	0.48	<0.001
Electronic health record systems	Adverse drug events	Quasi-experimental	12,501	0.26	0.31	<0.001
Computerized physician order entry	Medication errors	Randomized controlled trial	3,854	0.51	0.56	<0.001
Barcoding technology	Medication errors	Quasi-experimental	3,762	0.43	0.49	<0.001
Patient identification measures	Wrong-patient errors	Quasi-experimental	6,914	0.35	0.40	<0.001
Fall prevention measures	Falls with injury	Quasi-experimental	3,834	0.28	0.33	<0.001
Surgical safety measures	Adverse events	Quasi-experimental	4,283	0.38	0.43	<0.001
Infection control measures	Healthcare-associated infections	Quasi-experimental	12,315	0.46	0.53	<0.001
Staff training	Adverse events	Quasi-experimental	3,854	0.32	0.36	<0.001

Note: Effect size is reported as Cohen's d or the odds ratio (OR) where appropriate.

The Table 1 provides a summary of the effectiveness of different patient safety interventions in healthcare settings, as measured by their impact on specific outcome measures. The interventions include medication reconciliation, surgical safety checklists, hand hygiene programs, electronic health record systems, computerized physician order entry, barcoding technology, patient identification measures, fall prevention measures, surgical safety measures, infection control measures, and staff training.

The study designs used include quasi-experimental and randomized controlled trials, and the sample sizes range from 1,212 to 13,460. The effect size is reported as Cohen's d or the odds ratio where appropriate, and all interventions show significant improvements in the outcome measures with p-values of <0.001.

Overall, the table highlights the effectiveness of various patient safety interventions in healthcare settings. It provides evidence that implementing these interventions can significantly reduce medication errors, surgical complications, healthcare-associated infections, adverse drug events, wrong-patient errors, falls with injury, and adverse events. The results suggest that healthcare organizations should consider implementing these interventions to improve patient safety and reduce the risk of adverse events.

Effectiveness of Patient Safety Interventions in Healthcare Settings: Summary of Key Findings from a Systematic Review

The Table 1 provides a summary of key findings from the interventions evaluated aimed at improving patient safety in health care settings.

Table 2. A Summary Table of the Key Findings from the Systematic Review

Intervention	Outcome	Number of Studies	Key Findings
Medication reconciliation	Reduction in medication errors and adverse drug events	14	Medication reconciliation led to a significant reduction in medication errors and adverse drug events.
Surgical safety checklists	Reduction in surgical complications and mortality	8	Surgical safety checklists led to a significant reduction in surgical complications and mortality.
Hand hygiene programs	Reduction in healthcare-associated infections	12	Hand hygiene programs led to a significant reduction in healthcare-associated infections.
Electronic health record systems	Improved patient safety outcomes	7	Electronic health record systems led to improved patient safety outcomes, including a reduction in medication errors and adverse events.
Fall prevention measures	Reduction in falls and fall-related injuries	6	Fall prevention measures, including assessing patients' risk for falls, implementing fall prevention protocols, and educating patients and families on fall prevention, led to a significant reduction in falls

			and fall-related injuries.
Surgical safety measures	Reduction in adverse events	3	Measures to improve surgical safety, such as preoperative assessments, team briefings, surgical checklists, and postoperative debriefings, led to a significant reduction in adverse events.
Staff training	Improved adherence to patient safety practices	10	Staff training led to improved adherence to patient safety practices, including communication skills, infection control, and medication safety.

The Table 2 summarizes the key findings from a systematic review of patient safety interventions in healthcare settings. The interventions include medication reconciliation, surgical safety checklists, hand hygiene programs, electronic health record systems, fall prevention measures, surgical safety measures, and staff training.

The Table 2 indicates that all of these interventions were effective in improving patient safety outcomes, including reductions in medication errors, adverse drug events, surgical complications, mortality, healthcare-associated infections, falls, and adverse events. In addition, staff training was found to improve adherence to patient safety practices.

Overall, the review found that most interventions aimed at improving patient safety led to significant improvements in patient safety outcomes, including a reduction in adverse events and preventable harm. The key interventions that were found to be effective include medication reconciliation, surgical safety checklists, hand hygiene programs, electronic health record systems, fall prevention measures, surgical safety measures, and staff training. These interventions can help improve patient safety and reduce the risk of harm to patients in healthcare settings.

Overall, the findings suggest that healthcare organizations should consider implementing these interventions to improve patient safety outcomes and reduce the risk of adverse events. The results of the systematic review provide valuable information to inform evidence-based decision making in healthcare settings.

Effectiveness of Patient Safety Interventions in Healthcare Settings: a Summary of the Effectiveness of Different Patient Safety Interventions Evaluated and their Effect Size

The Table 3 presents a summary of the effectiveness of different patient safety interventions in healthcare settings and their effect size.

Table 3. A Summary of the Effectiveness of Different Patient Safety Interventions and their Effect Size

Intervention	**Outcome**	**Number of Studies**	**Effect Size (95% CI)**
Computerized Physician Order Entry (CPOE)	Medication errors	12	Reduction of 45% (34%-56%)
Teamwork Training	Adverse events	8	Reduction of 21% (12%-30%)
Hand Hygiene Improvement	Healthcare-associated infections	15	Reduction of 32% (23%-41%)
Patient	Patient safety culture	6	Improvement of 18%

Engagement/communication			(8%-28%)
Medication Reconciliation	Medication discrepancies	10	Reduction of 57% (45%-69%)
Surgical Safety	Surgical complications	6	Improvement of 60% (55%-75%)
Patient identification measures	Medical records errors	7	Reduction of 27% (22%-38%)
Fall prevention measures	Falls with injury	5	Improvement 66% (56%-72%)

The Table 3 presents a summary of the effectiveness of different patient safety interventions in healthcare settings. Computerized Physician Order Entry (CPOE) was found to reduce medication errors by 45%, based on 12 studies. Teamwork training showed a reduction of adverse events by 21% based on eight studies. Hand hygiene improvement was found to reduce healthcare-associated infections by 32% based on 15 studies. Patient engagement/communication was associated with an improvement of patient safety culture by 18% based on six studies. Medication reconciliation was found to reduce medication discrepancies by 57% based on ten studies. Surgical safety interventions were associated with a 60% improvement in surgical complications, based on six studies. Patient identification measures reduced medical records errors by 27% based on seven studies, while fall prevention measures showed a 66% improvement in falls with injury based on five studies.

Discussion

The present systematic review aimed to identify effective patient safety interventions across a range of healthcare settings. Our findings suggest that computerized physician order entry (CPOE), teamwork training, hand hygiene improvement, patient engagement, medication reconciliation, surgical safety, patient Identification measures, and fall prevention measures are promising strategies for reducing various patient safety issues.

CPOE was found to be effective in reducing medication errors by 45%. This finding is consistent with previous research that has also demonstrated the effectiveness of CPOE in reducing medication errors [15-17]. CPOE systems can improve patient safety by reducing errors in ordering, transcribing, and dispensing medications. Teamwork training was also effective in reducing adverse events by 21%. Effective communication and teamwork among healthcare providers can prevent adverse events and improve patient outcomes. This finding is consistent with previous research that has shown the effectiveness of teamwork training in improving patient safety [18].

Hand hygiene improvement interventions were found to be effective in reducing healthcare-associated infections by 32%. This is consistent with previous research that has demonstrated the importance of hand hygiene in preventing healthcare-associated infections [19]. Hand hygiene improvement interventions, including education and reminders, can be simple yet effective strategies to improve patient safety.

Patient engagement interventions were found to be effective in improving patient safety culture by 18%. Patient engagement can help to identify potential safety issues and promote patient-centered care. Our findings are consistent with previous research that has shown the effectiveness of patient engagement in improving patient safety [20].

Medication reconciliation interventions were found to be effective in reducing medication discrepancies by 57%. This finding is consistent with previous research that has shown the importance of medication reconciliation in preventing medication errors [21]. Medication reconciliation involves

comparing a patient's medication orders to all of the medications that the patient is taking to identify and resolve discrepancies.

Surgical safety is a critical aspect of patient safety in healthcare settings. The finding from the systematic review that surgical safety interventions led to a 60% improvement in surgical complications is consistent with previous studies. A systematic review by [22] found that the use of surgical safety checklists resulted in a significant reduction in surgical complications and mortality rates. Similarly, a meta-analysis by [23] found that the use of surgical safety checklists reduced surgical complications by up to 50%.

Patient identification measures are another important aspect of patient safety. The finding from the systematic review that patient identification interventions led to a 27% reduction in medical records errors is supported by previous studies. A systematic review by [24] found that patient identification interventions, such as barcode technology and wristband identification, led to a significant reduction in medical errors related to patient identification. Similarly, a study by [25] found that the implementation of barcode technology reduced the incidence of wrong-patient errors by 35%.

Fall prevention measures are essential in healthcare settings, particularly among older adults who are at a higher risk of falls and fall-related injuries. The finding from the systematic review that fall prevention interventions led to a 66% improvement in falls with injury is consistent with previous studies. A systematic review by [26] found that fall prevention interventions, such as multifactorial interventions that involve assessing patients' fall risk and implementing individualized fall prevention plans, led to a significant reduction in falls and fall-related injuries among older adults.

In conclusion, the findings from the systematic review are consistent with previous studies and support the implementation of interventions to improve patient safety in healthcare settings. The implementation of computerized physician order entry (CPOE), teamwork training, hand hygiene improvement, patient engagement, medication reconciliation, surgical safety interventions, patient identification measures, and fall prevention measures can significantly reduce surgical complications, medical records errors, and falls with injury, and improve patient engagement and safety measures respectively. These findings provide valuable insights for healthcare providers and policymakers in implementing patient safety interventions. These findings can inform the development and implementation of patient safety programs across different healthcare settings. However, further research is needed to evaluate the long-term effectiveness of these interventions and to identify the most effective implementation strategies.

In light of these findings, authors assert that patient safety is an essential aspect of healthcare delivery that requires a coordinated effort from healthcare providers, administrators, and policymakers to ensure that patients receive safe and high-quality care. A focus on patient safety can help to prevent medical errors, reduce costs, and improve patient outcomes, making it a critical area for ongoing research and development in the healthcare industry.

Conclusion

Patient safety has become a significant focus of the healthcare industry due to the risks of adverse events and errors during the provision of healthcare services [3, 11, 13]. This systematic review provides a comprehensive evaluation of interventions aimed at improving patient safety in healthcare settings. The review identified 50 studies that evaluated various interventions, including medication reconciliation, surgical safety checklists, hand hygiene programs, and electronic health record systems. The results indicate that most interventions led to significant improvements in

patient safety outcomes, including a reduction in adverse events and preventable harm.

Effective communication is a crucial aspect of patient safety, including clear communication of medication information, medical history, and test results [2, 5, 13, 14]. The review highlights the importance of hand hygiene in preventing the spread of infection, which is one of the most effective ways to reduce healthcare-associated infections. The review also found that measures to improve medication safety, such as computerized physician order entry, medication reconciliation, and barcoding technology, can significantly reduce medication errors.

Proper patient identification is essential before any procedure or treatment is administered, and measures to prevent falls, such as assessing patients' risk for falls, implementing fall prevention protocols, and educating patients and families on fall prevention, can significantly reduce the risk of harm to patients [13, 15]. Surgical procedures can also pose risks to patients, and measures to improve surgical safety, such as preoperative assessments, team briefings, surgical checklists, and postoperative debriefings, can significantly reduce adverse events [2, 3, 8].

Infection control is another crucial aspect of patient safety, and measures to prevent infections, including hand hygiene, use of personal protective equipment, and proper cleaning and disinfection of equipment and facilities, can significantly reduce healthcare-associated infections [11, 16, 17]. Staff training is also essential in ensuring that healthcare providers receive ongoing training to stay up to date on the latest patient safety practices and techniques, including communication skills, infection control, medication safety, and other relevant topics [3, 6, 19, 20].

In conclusion, the findings of this systematic review suggest that interventions aimed at improving patient safety can be effective in reducing adverse events and preventable harm in healthcare settings. Evidence-based measures to improve patient safety include effective communication, hand hygiene, medication safety, patient identification, fall prevention, surgical safety, infection control, and staff training. The implementation of these measures can help improve patient safety and reduce the risk of harm to patients in healthcare settings. Further research is needed to identify the most effective interventions and to evaluate the long-term impact of these interventions on patient outcomes.

Evidence based Measures to Improve Patient Safety

Improving patient safety is a critical aspect of healthcare and can help to prevent medical errors, reduce costs, and improve patient outcomes. Evidence-based measures to improve patient safety include:

Communication

Healthcare professionals must ensure effective communication between patients and their caregivers, among healthcare team members, and across healthcare settings [11, 12, 14]. This includes clear communication of medication information, medical history, and test results.

Hand Hygiene

Hand hygiene is one of the most effective ways to prevent the spread of infection [2, 5, & 11]. Healthcare providers should wash their hands frequently, especially before and after patient care.

Medication Safety

Medication errors can be a significant cause of harm to patients [8, 10]. Measures to improve medication safety include the use of computerized physician order entry (CPOE), medication reconciliation, and barcoding technology.

Patient Identification

Patients must be properly identified before any procedure or treatment is administered [2,

5, 7]. This includes using two patient identifiers, such as name and date of birth, to ensure accuracy.

Fall Prevention

Falls are a common cause of injury in hospitals and other healthcare settings [2, 11]. Measures to prevent falls include assessing patients' risk for falls, implementing fall prevention protocols, and educating patients and families on fall prevention.

Surgical Safety

Surgical procedures can be complex and pose risks to patients [2, 3, 8]. Measures to improve surgical safety include preoperative assessments, team briefings, surgical checklists, and postoperative debriefings.

Infection Control

Infections can be a significant cause of harm to patients in healthcare settings [4, 5]. Measures to prevent infections include hand hygiene, use of personal protective equipment (PPE), and proper cleaning and disinfection of equipment and facilities.

Staff Training

Healthcare providers must receive ongoing training to stay up to date on the latest patient safety practices and techniques [3, 6, 18]. Training should include communication skills, infection control, medication safety, and other relevant topics. These evidence-based measures can help improve patient safety and reduce the risk of harm to patients in healthcare settings.

Conflict of Interest

This study was neither funded nor sponsored by any organization. Therefore, authors declare no conflict of interest in the publication of this article.

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Revisiting the Endogeneity of Adolescent Pregnancy and Child Marriage in Low- and Middle-Income Countries: A Review with Practical Solutions

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Abstract

Adolescence is an important time for promoting health and preventing disease. The World Health Organization (WHO) defines an adolescent as an individual in the 10-19 years age group and usually uses the term young person to denote those between 10 and 24 years. Adolescent health encompasses changing transitions within multiple domains, including the physical, social, emotional, cognitive, and intellectual. These changes have important implications for health. During this period of increasing independence, adolescents face critical choices about health-related behaviors in areas such as sexuality, physical activity, diet, and use of health care services. These behaviors affect health during adolescence and young adulthood and, in the long-term, are related to many of the leading causes of adult morbidity and mortality. Therefore, the protection and promotion of health during this life stage is of great importance and has been shown to yield benefits not only for adolescents now, but also for their future adult lives and for their future children. This paper explore two key issues underpinning adolescent health, teen pregnancy, and child marriage. Trends in early marriage and early childbearing help determine national poverty levels and economic productivity. Decisions about whether to remain in school, whether to marry, or whether to engage in sexual activity have implications for education and health. The paper argues that failure to understand the interrelationship between adolescent pregnancy and child marriage may jeopardize earlier investments in maternal and child health, erodes future quality and length of life, and escalates suffering, inequality, and social instability.

Keywords*: Adolescent Health, Child Marriage, Teen Pregnancy.*

Introduction

Adolescent pregnancy, child marriage and teen motherhood continue to be major adolescent health and development concerns in developing countries. Every year it is estimated that 21 million girls aged 15–19 years in low- and middle-income countries (LMICs) become pregnant, of which approximately 50% were unintended and resulted in an estimated 12 million births [1]. The prevalence of teen pregnancy, or adolescent pregnancy can be defined using adolescent birth rate. This is defined as the number of live births to women ages 15-19 per 1000 women [2]. Although global adolescent birth rates are falling, they are either stagnant or increasing in several countries in Sub Saharan Africa (SSA) and South Asia [3-5]. Huda M M et al. observed that the adolescent fertility rate (birth rate per 1000 girls and young women aged 15–19 years) over the period 2015–2020 was the highest in the sub-Saharan Africa (SSA) region at 102.8 births per 1000 person-years, far higher than the global average (44 per 1000), followed by South Asia with 26 births per 1000 girls aged 15–19 [5]. As the global population of adolescents continues to grow, projections

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indicate that the number of adolescent pregnancies will increase globally by 2030, with the greatest proportional increases in West and Central Africa and Eastern and Southern Africa [6-7]. The projected increase in adolescent pregnancies is likely to be more prevalent in sub-Saharan Africa (SSA), which already leads the world in teen pregnancies [8-9] and child marriage [10].

The prevention of teenage pregnancies and teenage motherhood should therefore be a priority for public health in developing countries. The WHO [11:1] underscore that "preventing pregnancy among adolescents and pregnancy-related mortality and morbidity are foundational to achieving positive health outcomes across the life course and imperative for achieving the Sustainable Development Goals (SDGs) related to maternal and newborn health". UNFPA argue that this is because "when a girl becomes pregnant, her life can change radically. Her education may end, and her job prospects diminish. She becomes more vulnerable to poverty and exclusion, and her health often suffers" [12:1]. It is widely recognized that adolescent girls face serious health risks when giving birth at an early age [13]. Teenage mothers, especially those under the age of 18, have been shown to be more likely to suffer from pregnancy and delivery complications than older mothers, resulting in higher morbidity and mortality for both them and their children [14, 15]. Complications during pregnancy and childbirth are the leading cause of death for 15- to 19-year-old girls globally [11]. Abortions, which are highly restricted or prohibited in many countries can be unsafe and result in illness and death. Every year, some 3.9 million girls aged 15 to 19 years undergo unsafe abortions, thereby contributing to maternal mortality, morbidity, and lifelong reproductive health problems [16].

WHO [11] state that adolescent mothers (ages 10 to 19 years) face higher risks of eclampsia, puerperal endometritis, and systemic infections than women aged 20 to 24 years, and babies born to adolescent mothers face higher risks of low birth weight, preterm delivery, and severe neonatal conditions than those born to women aged 20 to 24 years. In its new report UNICEF [17] point out that inadequate nutrition during adolescent pregnancy can lead to weakened immunity, poor cognitive development, and an increased risk of life-threatening complications – including during pregnancy and childbirth – with dangerous and irreversible consequences for their children's survival, growth, learning, and future earning capacity. Overall, infant mortality and morbidity among children born to mothers under the age of 18 is higher as compared to those born to older mothers [10], [18]. Teen pregnancy has large economic impacts on society. The children who are born to teen mothers have many learning problems. Teenage mothers also give birth to children who have a larger risk for health problems such as lower birth weights and reach developmental milestones slower [19]. Several studies indicate that children of adolescent mothers are also more likely to have poor nutritional status when they are born and throughout their childhood [20]. The UNICEF [17] report indicate that 51 million children under 2 years suffer stunting globally, meaning they are too short for their age due to malnutrition. The report further observes that about half of these children become stunted during pregnancy and the first six months of life, the 500-day period when a child is fully dependent on maternal nutrition [17]. These children are further disadvantaged because women married as children tend to have less spacing between births, as well as more children over their lifetimes than those married later, which can also negatively impact child health [17].

Adolescent pregnancy also has negative social and economic effects on girls, their families, and communities [21]. Unmarried pregnant adolescents may face stigma or rejection by parents and peers and threats of violence. Child sexual abuse increases the risk

of unintended pregnancies. A WHO report dated 2020 estimates that 120 million girls aged under 20 years have experienced some form of forced sexual contact. The report states that this abuse is deeply rooted in gender inequality; it affects more girls than boys, although many boys are also affected [11]. Estimates suggest that in 2020, at least 1 in 8 of the world's children had been sexually abused before reaching the age of 18, and 1 in 20 girls aged 15–19 years had experienced forced sex during their lifetime [11]. Similarly, girls who become pregnant before age 18 are more likely to experience violence within marriage or a partnership [3, 19]. The teenage mothers or fathers are often unprepared for parenthood and drop out of school, taking low-paying jobs and never completing their education [22]. With regards to education, school-leaving can be a choice when a girl perceives pregnancy to be a better option in her circumstances than continuing education or can be a direct cause of pregnancy or child marriage [10, 22].

In the meantime, Child marriage, defined as marriage of a child <18 years of age (marriage where one or both partners are under the age of 18 prevalence remains high in some countries [19]. In many cases, child marriage is a driver of early pregnancy; in others – particularly where sex outside of marriage is taboo – unintended pregnancy drives child marriage (Presler-23, 24). Every year, approximately 15 million around the world are married before their 18th birthday [19]. This equates to one out of every five girls, with over 650 million women alive today who were married as children [19]. Adolescent fertility rates are generally higher in settings where early marriage is prevalent, in rural rather than urban areas, and among girls with less educational attainment and lower socio-economic status [25, 26]. Studies show that pregnant adolescents often get married to 'save face', while arranged child marriage remains a norm in some cultural groups. UNICEF note that in South Asia and Africa, child marriage often drives early pregnancy, in East Asia and the Pacific, pregnancy may also precede marriage, and act as a trigger for child marriage or early union [19, 20].

Child marriage happens across countries, cultures, and regions, but the practice is most prevalent in developing countries where poverty, tradition, and lack of opportunity keep it alive [28, 29]. Parents want to ensure their daughters' financial security; however, daughters are considered an economic burden [22]. Nour, NM [22] notes that feeding, clothing, and educating girls is costly, and girls will eventually leave the household. According to Nour, NM [22] a family's only way to recover its investment in a daughter may be to have her married in exchange for a dowry. Mensch et al. [30] point out that in some countries, the dowry decreases as the girl gets older, which may tempt parents to have their daughters married at younger ages. UNICEF [19] stress that child marriage is a human rights violation that prevents girls from obtaining an education, enjoying optimal health, bonding with others their own age, maturing, and ultimately choosing their own life partners. Girls who marry young tend to be from poor families and to have low levels of education [28]. Child marriage has many effects on girls' health: increased risk for sexually transmitted diseases, cervical cancer, malaria, death during childbirth, and obstetric fistulas [22, 28]. Girls' offspring are at increased risk for premature birth and death as neonates, infants, or children.

Child marriage also has social effects on girls. Nour NM [22] point out that if they marry men outside their village, they must move away [22:2, 28] further notes that "coping with the unfamiliar inside and outside the home creates an intensely lonely and isolated life. As these girls assume their new roles as wives and mothers, they also inherit the primary job of domestic worker. These young girls are typically financially dependent on their husbands, they often lack the agency to

advocate for themselves, especially when it comes to condom use and family planning, and they are more likely to experience domestic violence [22, 28]. Nour NM [22] states that because the husband has paid a hefty dowry, the girl also has immediate pressure to prove her fertility. Girls often embrace their fate and bear children quickly to secure their identity, status, and respect as an adult [22, 28]. Girls who marry young will likely have more children than women who have their first child as an adult. One study showed that a girl who marries at 13 will have 26% more children than a girl who marries at 18 or older [31]. As a result, these young girls have high total fertility rates but have missed the opportunities to be children: to play, develop friendships, bond, become educated, and build social skills [28, 31]. Increased fertility rates contribute to overpopulation, and as the global population continues to surge, poverty, unrest, and environmental degradation will follow in tandem [22]. Unfortunately, poor mothers with large families often struggle to support their families, putting those children at increased likelihood of lifelong poverty, high fertility rates and child marriage [28, 31]. Creating these vicious cycles of poverty lay eggs and fuels intergenerational poverty.

Problem Statement / Introduction

This white paper argues that adolescent pregnancy and child marriage in low- and middle-income countries presents a severe impediment to development and can lead to perpetuate gender inequality, school dropout, lost productivity, poor adolescent health outcomes and the intergenerational transmission of poverty. This is critical consideration within the adolescent health literature, policy, and practices especially that present adolescents are the largest population in history and adolescent girls are the most threatened and vulnerable with regards teenage pregnancy and child marriage. Considering that global population of adolescents is projected to grow with indication that the number of adolescent pregnancies and child marriage will continue to increase globally by 2030, with the greatest proportional increases in West and Central Africa and Eastern and Southern Africa. Therefore, preventing adolescent pregnancy and childbearing as well as child marriage is crucial to achieve SDG agenda as dedicated under indicators 3.7.2, “Adolescent birth rate (aged 10–14 years; aged 15–19 years) per 1000 women in that age group,” and 5.3.1, and “Proportion of women aged 20–24 years married before the age of 18 years”.

Recognizing that adolescent pregnancy and childbirth have adverse health and wellbeing consequences for mothers and their children. This paper raises serious concerns for adolescent pregnancy and child marriage that have consequences on maternal mortality and morbidity due to pregnancy complications and unsafe abortion including violation of girl’s rights. The paper points out the increasingly risks of children born to adolescent include premature birth, death, malnutrition, and low physical and mental development. Linking the endogeneity of adolescent pregnancy and child marriage compromises a girl’s development by resulting in early pregnancy and social isolation, interrupting her schooling, limiting her opportunities for career, and placing her at risk of violence. This paper suggests that the practice of child marriage is closely associated with lower educational attainment, early pregnancies, intimate partner violence, maternal and child mortality, increased rates of sexually transmitted infections, intergenerational poverty, and the disempowerment of adolescent girls.

Thus, prevention of adolescent pregnancy through improving access to sexual and health care services is crucially important as outlined in the 2030 UN SDGs and the UN Global Strategy for Women’s, Children’s, and Adolescent’s Health. However, this paper recognizes that there are huge problems for many adolescent health needs, including sexual

and reproductive health which continue to be overlooked in addressing adolescent pregnancy and child marriage. Firstly, adolescents face significant barriers that undermine their sexual and reproductive health and rights—including lack of access to comprehensive sexuality education and to essential sexual and reproductive health services. A significant proportion of adolescents in SSA and South Asia do not access nor utilize contractive services for prevention of pregnancy, which is a consequence of several individual, interpersonal, institutional, and systemic factors [32]. Mekonnen, et al. [32:1] emphases that "the utilization of mainstream maternal [and adolescent] health services have a significant impact on the reduction of death and morbidity, [prevention of teen pregnancies] through early detection of danger signs and management of potential complications [as well as provision of adolescent contraceptive services]. They note that "maternal health care encompasses a range of services including antenatal care, skilled birth delivery care, and postnatal care" [32:1]. They add that "the provision of these services by formally trained and accredited health care professionals improves adolescent pregnancy outcomes significantly" [32:1].

However, in SSA and South Asia adolescents continue to face barriers to access contraception services due to restrictive laws and policies regarding provision of contraceptive based on age or marital status [33, 34]. Studies from several countries indicate that when adolescents approach clinics for help, they are often scolded, refused information, or turned away [33, 34]. They fear being seen by an adult family member or neighbors. Many are simply too young and inexperienced to know how to find a clinic. As a result of these barriers, adolescents often first contact a sexual and reproductive health programme when they must deal with a pregnancy or a sexually transmittable disease [33, 34]. This is further compounded by structure challenges such as inadequate and or unskilled health workers include health worker bias towards adolescents, long waiting time and lack of confidentiality at health facilities, in addition to the cost and misconceptions about contraceptives, and non-friendly adolescent reproductive services [33, 35]. These problems are elevated further due to lack of willingness to acknowledge adolescents' sexual health needs, and adolescents' own inability to access contraceptives because of knowledge, transportation, and financial constraints [33, 36]. Onukwugha (37) noted the lack of awareness and education about contraception, sexually transmitted infections, and timely safe abortion are known to be the core reasons behind teen pregnancies. Apart from these, there appears to be a taboo associated with sex-related subjects in certain societies and cultures because of which the parents fail to educate their children regarding the same [33, 37].

Additionally, adolescents face barriers that prevent use and/or consistent and correct use of contraception, even when adolescents are able to obtain contraceptives: pressure to have children; stigma surrounding non-marital sexual activity and/or contraceptive use; fear of side effects; lack of knowledge on correct use; and factors contributing to discontinuation (for example, hesitation to go back and seek contraceptives because of negative first experiences with health workers and health systems, changing reproductive needs, changing reproductive intentions [33]. The further barriers are due to a lack of sex education and family planning and a lack of the ability to put that knowledge into effect [33]. This is also attributed to lower education status, low socioeconomic class, and poverty which also increase the rates of such pregnancies [33, 37]. Sexual abuse, peer pressure to have sex, lower self-esteem, depression, lower knowledge of contraceptives, and substance abuse also increase adolescent pregnancies. [33] observed that even when adolescents can obtain contraceptives, they may lack the agency

or the resources to pay for them, knowledge on where to obtain them and how to correctly use them. They may face stigma when trying to obtain contraceptives. Further, they are often at higher risk of discontinuing use due to side effects, and due to changing life circumstances and reproductive intentions [33]. Early initiation of sexual activity and marriage at an early age with a partner of older age increases the likelihood of conception in the absence of contraception among adolescents in stable relationships, marriage, or union compared to those who are not [33].

This paper recognizes importance of ending child marriage to achieve Sustainable Development Goal (SDG) 5: Achieve gender equality and empower all women and girls. Target 5.3 which seeks to end child, early and forced marriage by 2030. The paper recognize that child marriage also hinders the realization of many other SDGs, especially those related to education and health. However, several factors that contribute to child marriage remain unresolved. First, in many societies, girls are under pressure to marry and bear children. As of 2021, the estimated global number of child brides was 650 million. The paper argues that child marriage places girls at increased risk of pregnancy because girls who are married very early typically have limited autonomy to influence decision-making about delaying child-bearing and contraceptive use [38]. Second, in many places, girls choose to become pregnant because they have limited educational and employment prospects [22, 39]. Often in such societies, motherhood – within or outside marriage/union – is valued, and marriage or union and childbearing may be the best of the limited options available to adolescent girls [33, 40]. The biggest problem is that gender norms and unequal power relations between girls and boys remain key drivers of teenage pregnancy and child marriage (Psaki et al.,2021). Norms may also be closely connected to other drivers of child marriage, such as lack of opportunity or agency and fear of pregnancy [33, 40, 41]. In some settings girls may have little control over the decision to marry, perhaps reflecting strong social norms in support of child marriage (Psaki et al.,2021. For girls, both identifying the goal of delaying marriage and acting on it may present challenges, especially in settings with limited information about the consequences of child marriage and limited availability of alternative pathways [33, 40, 41].

Poverty plays a central role in perpetuating child marriage. Poverty drives unemployed parents to regard girl-children as economic burdens, both about education costs and the practice of a dowry system [33,40, 41], which is a financial transaction entered into at the time of marriage. Child marriage is therefore often viewed as a means of reducing the financial burden for parents and as a source of income [41]. Additionally, child marriages form new alliances between tribes, clans, and villages; reinforce social ties; and stabilize vital social status [22, 41]. Parents worry about ensuring their daughters' virginity and chastity [22, 39]. Child marriage is also seen as a protective mechanism against premarital sexual activity, unintended pregnancies, and sexually transmitted diseases (STDs). The latter concern is even greater in this era of HIV/AIDS [22, 41].

The legislative framework for protecting children from early marriage is weak in SSA and South Asia with few countries categorically prohibiting marriage below the age of 18, allowing no exceptions based on sex, religion, ethnicity, or parental consent [19, 22, 41]. Cultural practices may also shape the sexual behaviour of young people. One of the common cultural practices involving young people is the initiation ceremony or puberty rite. The process of initiating a girl plays a significant role in shaping her perception of sex and sexuality [41, 42]. [42] assets that initiation rituals are mainly aimed at facilitating young people's transition into adulthood where topics such as marital roles are addressed including

information around sexuality, sexual relations, and pleasure. They point out that concerns have been raised about the values inculcated into a woman about sex and sexuality during this rite [42]. Child marriage is most common among the poorest segments of society and its prevalence is highest in low-income countries [19, 22, 41]. At the same time, high rates of child marriage negatively affect a country's economic growth and ability to eradicate poverty through their impact on fertility and population growth, maternal and child health and women's potential earnings and productivity [19, 22, 41].

Proposed Solution(s)

Introduction of Solution

This white paper notes that child marriage and adolescent pregnancy remain major social and public health issues in low- and middle-income countries, with far-reaching implications for the wellbeing of children and adolescents. Adolescent pregnancy, often driven by child marriage, remain urgent issues demanding urgent solutions owing to eminent risks of maternal and newborn complications and its overall impact that limit girls' opportunities to education. For adolescent girls (aged 10–19 years old), experiencing adolescent health challenges means facing harsh social sanctions and difficult choices that have life-long consequences. It could mean dropping out of school; being shamed and stigmatized by family, community members and peers; increased vulnerability to violence and abuse, increased exposure, and risk to STIs and HIV/AIDS, greater poverty, and economic hardship and at worst death. Therefore, as part of the broader solutions to comprehensively address adolescent health, adolescence needs to be recognized as an integral part of all policies at global, national, and sub-national levels. This paper has established that the enablers – policies and legislation have not fully recognized the adolescent as a unique demographic segment in society and do not offer sufficient support and protection to adolescents.

The paper, therefore, propose that the first solution as a matter of urgency, is to ensure that policies and laws are in place to protect adolescents specially when it comes to their access to sexual reproductive health services, contraceptive, and comprehensive education sexuality information. Contraceptive use is an important means of avoiding, spacing, or delaying childbearing. The prevalence of contraceptive use is typically lower among sexually active adolescents as highlighted in this paper. Therefore, there is a need to address the legal and policy barriers. Several studies document legal and policy-related barriers including laws that do not allow contraception for adolescents and lack of knowledge among providers and adolescents themselves of the legal rights of adolescents to obtain contraception [16, 33, 43, 44]. Governments and partners are urged to ensure that adolescents, both boys and girls, receive adequate education, including family life and sex education, with due consideration given to the role, rights and obligations of parents and changing individual and cultural values. Suitable and age appropriate SRH and family planning information and services be made available to adolescents within the changing sociocultural framework of each country.

In 2011, WHO issued Guidelines on preventing early pregnancy and poor reproductive outcomes in adolescents in developing countries. To accelerate progress towards attainment of international development goals and targets in sexual and reproductive health, and to contribute to meeting unmet need for contraceptive information and services among adolescents. There is urgent need to ensure that these laws are in line with WHO Guideline and ensure that are adolescent friendly and recognize the unmet needs of adolescent to access contraceptive services. This critical investments for building

an enabling environment should reflect adolescent legal rights in laws, policies, and guidelines that respect, protect, and fulfill adolescents' human rights to contraceptive information, products, and services regardless of age, sex, marital status, or parity. Governments and partners must address the supply side of services – that is limited health service delivery points for adolescents at health facilities and a lack of comprehensive sexuality education in communities and schools, an inadequate number of suitably trained health workers and a weak supply chain. The immediate solution for this is also to ensure that have primary health care services is well resourced and equipped to meet the needs of adolescent health including investment in skilled health workforce, so that services respond to adolescents' needs that are often context specific. These can be reinforced with clear guidelines that support health professionals to provide services and information to adolescents [32, 36, 42]. For legal rights and adolescent-related health policies to be operationalized at the service delivery level, the facility should have copies of relevant service delivery policies and standards (e.g., adolescent-friendly service provision standards) and providers should be well oriented on their use as part of adolescent health professional training or staff updates [39, 40]. In addition, supervision checklists should reflect key provisions of these policies, and supervisors should reinforce their application during supervision visits [39, 40].

Studies have shown that while adolescent friendly centers may serve the useful purpose of providing a venue to bring adolescent together and to conduct small group learning and sharing experiences, they do not lead to increases in contraceptive uptake and SHR including family planning services [33, 36]. In delivering SRH, contraceptive and family planning information and services programme and intervention need to use multiple service modalities to reach a wider range of adolescents [33]. Such approaches can include community-based distribution, mobile outreach services, drug shops, informal settings, schools, or workplace-based services. This entails creating safe spaces and community-based intervention for encouraging adolescents to participate and attend. Emphases should be placed on linking service delivery with activities that build support within communities. Interventions directed at influencing the sexual and reproductive health behaviors of adolescents are significantly enhanced where there are complementary interventions for parents, providers, religious leaders, and other influential adults who can foster a supportive environment in health facilities, schools, religious places of worship, and in homes [45]. Successful adolescent programmes that address teen pregnancy and child marriage are those which tend to involve male adolescents through dialogue about sexual health, risky behaviors, and STIs. Thus, investment that encourages adolescent boys to use condoms to prevent pregnancies and diseases play a critical role especially if it focuses on educating them about other methods of contraception and postcoital contraception including helping them to create positive relationship with girls and address power, violence and masculinity all help teenage boys understand their responsibilities as a partner.

Secondly, shifting social norms and fostering support among communities and parents for adolescents to access contraceptive information and services; and addressing gender norms. Gender ideologies influence how adolescent boys and girls behave and decide about contraception. According to social beliefs, adolescent girls are often discouraged from being open about any sexual activity; however, adolescent boys are encouraged to do the opposite. The same ideologies come forward when it comes to the use of contraception and SRH [41, 45]. These gender gaps often suppress adolescent girls' desires and views, leading to increased teenage

pregnancies. In practice, practical solutions ought to support adolescents to talk openly about their feelings and experiences related to sexuality. Educate them on topics, such as HIV, STDs, and contraception including spread awareness in the field of effective contraceptive usage and shedding social stigma including educating them on contraception use. Interventions and programmes should endeavor to bring families and communities together through community dialogues/discussions to address topics on sexuality without any socio-cultural resistance. These community dialogues ought to be open about health risks of unprotected sex and teenage pregnancies. Adolescents' perceptions of feeling loved, and of feeling supported, are very important. Creating awareness and enabling an environment where parents are prepared for raising an adolescent with a positive approach and support as well as being their friends.

A good parent-child relationship can make children happy and confident. They will understand their responsibilities and social values. There is need to encourage having counseling and free spaces for adolescents in schools and apprising teachers about how to handle adolescents who need support outside their homes and making sure that early childhood development programs are linked with adolescent health programs too. Taken together, these elements of adolescent-friendly contraceptive services, encompassing service delivery, community-based approach and enabling environment aspects, need to be considered to increase adolescent uptake of contraception, SRH and family planning service and information.

Further, governments that have not yet heeded the call to set the legal minimum age for marriage, must set the legal age of marriage to 18 for both girls and boys and enforce these laws to protect children in line with international commitments such as the Convention on the Rights of the Child. Ensure that policies for education promote free and universal education. Education of girls is critical to ending child marriage. Child marriage is intricately linked to issues of value, power, and control [23]. Educated girls are less likely to marry early and are more employable, allowing them to have more control over their lives. Education not only delays marriage, pregnancy, and childbearing, but school-based sex education can be effective in changing the awareness, attitudes, and practices leading to risky sexual behavior in marriage [19, 33]. Education helps them take care of their families in a better way and positively impact society. Empowerment programs, which aim to increase girls' agencies and equip them with knowledge and skills to avoid child marriage [19]. Several studies indicate that community engagement programs, which aim to address social norms by sensitizing parents and community members to the risks of child marriage; encourage support for girls continued education as an alternative to marriage including economic support programs and soft conditional cash transfer which aim to alleviate economic pressures and offer financial incentives for certain behaviors (e.g., delaying marriage, keeping girls in school have proved to be more effective in addressing child marriage. It is well recognized that girl's empowerment by offering them support and protection together with effective strategies that teach life skills, build self-esteem, and improve social networks [19, 33].

Many girls marry early because of their poor economic conditions and sexual violence contribute to child marriage. Government must make efforts to change social norms and attitudes towards forced sex and sexual violence prevailing in society and promote gender equality.

Application of Solution

Several studies have shown effectiveness and reduction of adolescent pregnancy where contraceptive uptake among adolescents was high [43]. According to WHO studies

conducted in China, India, Kenya, Thailand, and other countries, adopting effective contraceptive methods (condoms, hormonal, and emergency contraceptives) can help prevent teenage pregnancies. Studies have shown that adolescent girls with access to contraception in settings where gender norms have been transformed to allow girls to know about sexual and reproductive health and to feel empowered to access services (24). Adolescent boys have higher uptake where access to contraception in settings where boys feel some sense of responsibility to plan pregnancies [24].

Studies have shown that countries that set their legal minimum age of marriage, their legal minimum age of marriage with parental consent, and their legal minimum age of sexual consent at 18 or older have rates of child marriage 40% lower than countries that haven't. Girl as Bride [46:1] state that "looking at the effects of child marriage laws in 12 sub-Saharan African countries, we found that countries that consistently protect the rights of girls by setting their legal minimum age of marriage, their legal minimum age of marriage with parental consent, and their legal minimum age of sexual consent at 18 or older had rates of child marriage and adolescent birth that were 40 per cent and 25 per cent lower than countries where these laws contradicted one another".

Future Direction / Long-Term Focus

The literature indicates that there is a gap in understanding the experiences of teen mothers in relation to childcare and their nutritional health. The gap in knowledge demands that more analysis is needed for adolescent mothers and their children.

This paper proposes further research on adolescent mothers and childcare including their nutritional health of both the mother and the child. Adequate nutrition is essential to maintain health at every stage of life. Nutritional needs differ across various age groups and with certain health conditions. Adolescent childbearing is on such instance in which nutritional needs differ. The growing adolescent and child also has distinct nutritional needs.

Results/Conclusion

This white paper argues that adolescent pregnancy and child marriage in low- and middle-income countries presents a severe impediment to development and can lead to perpetuate gender inequality, school dropout, lost productivity, poor adolescent health outcomes and the intergenerational transmission of poverty. Every year it is estimated that 21 million girls aged 15–19 years in low- and middle-income countries (LMICs) become pregnant, of which approximately 50% were unintended and resulted in an estimated 12 million births. In the meantime, Child marriage, defined as marriage of a child <18 years of age (marriage where one or both partners are under the age of 18 prevalence remains high in some countries. In many cases, child marriage is a driver of early pregnancy; in others – particularly where sex outside of marriage is taboo –unintended pregnancy drives child marriage. Every year, approximately 15 million people around the world are married before their 18th birthday. This equates to one out of every five girls, with over 650 million women alive today who were married as children. This is critical consideration within the adolescent health literature, policy, and practices especially that present adolescents are the largest population in history and adolescent girls are the most threatened and vulnerable with regards teenage pregnancy and child marriage. Considering that global population of adolescents is projected to grow with indication that the number of adolescent pregnancies and child marriage will continue to increase globally by 2030, with the greatest proportional increases in West and Central Africa and Eastern and Southern Africa. Therefore, preventing adolescent

pregnancy and childbearing as well as child marriage is crucial to achieve SDG agenda as dedicated under indicators 3.7.2, "Adolescent birth rate (aged 10–14 years; aged 15–19 years) per 1000 women in that age group," and 5.3.1, and "Proportion of women aged 20–24 years married before the age of 18 years."

This paper has highlighted that adolescent pregnancy, often driven by child marriage, remain an urgent issues recuring urgent solution owing to eminent risks of maternal and newborn complications and its overall impact that limit girls' opportunities to education. The paper argues that for adolescent girls (aged 10–19 years old), experiencing adolescent health challenges means facing harsh social sanctions and difficult choices that have life-long consequences. It could mean dropping out of school; being shamed and stigmatized by family, community members and peers; increased vulnerability to violence and abuse, increased exposure, and risk to STIs and HIV/AIDS, greater poverty, and economic hardship and at worst death. The paper notes that adolescent pregnancy tends to be higher among those with less education or of low economic status. Further, there is slower progress in reducing adolescent first births amongst these and other vulnerable groups, leading to increasing inequity. Child marriage and child sexual abuse place girls at increased risk of pregnancy, often unintended. The paper assets that in many places, barriers to obtaining and using contraceptives prevent adolescents from avoiding unintended pregnancies. It further states that there is growing attention to improving access to address adolescent pregnancy and child marriage. Therefore, as part of the broader solutions to comprehensively address adolescent health, adolescence needs to be recognized as an integral part of all policies at global, national, and sub-national levels. This paper has established that the enablers – policies and legislation have not fully recognized the adolescent as a unique demographic segment in society and do not offer sufficient support and protection to adolescents.

The paper, therefore, propose that the first solution as a matter of urgency, is to ensure that policies and laws are in place to protect adolescents specially when it comes to their access to sexual reproductive health services, contraceptive, and comprehensive education sexuality information. Several studies document legal and policy-related barriers including laws that do not allow contraception for adolescents and lack of knowledge among providers and adolescents themselves of the legal rights of adolescents to obtain contraception. Governments and partners are urged to ensure that adolescents, both boys and girls, receive adequate education, including family life and sex education, with due consideration given to the role, rights and obligations of parents and changing individual and cultural values. Suitable and age appropriate SRH and family planning information and services be made available to adolescents within the changing sociocultural framework of each country.

Secondly, shifting social norms and fostering support among communities and parents for adolescents to access contraceptive information and services; and addressing gender norms. In practice, practical solutions ought to support adolescents to talk openly about their feelings and experiences related to sexuality. Educate them on topics, such as HIV, STDs, and contraception including spread awareness in the field of effective contraceptive usage and shedding social stigma including educating them on contraception use. Interventions and programmes should endeavor to bring families and communities together through community dialogues/discussions to address topics on sexuality without any socio-cultural resistance. These community dialogues ought to be open about health risks of unprotected sex and teenage pregnancies.

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Acknowledgement and Conflict of Interest

The opinions expressed in this publication are those of the author. They do not purport the reflection the opinion or the view the Barnabas Research and Training Institute (BRTI). In this view the Author declare conflict of interest as it may underpin the Barnabas Research and Training Institute. The Author acknowledge all the sources have appropriately been referenced accordingly without option and where such happens it is not deliberate, and all those sources and works can well be acknowledged. Finally, this paper has not been submitted for any other publication and it is the original work of the author.

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Factors Associated with Accessibility and Utilization of Adolescent Health Services in Chingola, Zambia

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Abstract

The purpose of this paper was to explore the factors associated with accessibility and utilization of adolescent health services in Chingola, Zambia. The study was done among secondary school students in their junior and senior grades. Data were collected from four focus group discussions and four key informants' interviews. Data management analysis principles illuminating verbatim quotations are used to illustrate findings. The study findings indicate that lack of information and stigmatization were some of the factors identified to be the barriers to adolescents' health. The paper further outlines the proposed solutions which include establishing and strengthening the linkage between the schools and health facilities adolescent health services and creating awareness among the adolescents. Further, the paper gives the future direction that clinics and health centres should take advantage of technology and use electronic means to increase awareness of available reproductive health services for adolescents and that they should have door to door programs for the community aimed at sensitizing adolescents on reproductive health. In conclusion, it is indicated that improving the utilization of adolescent health services is a global dream. This dream can be realized only if the efforts are made to reach the adolescent population.

Keywords: *Accessibility, Adolescent Health Services, Stigmatization, Utilization.*

Introduction

The World Health Organization (WHO) [1] defines adolescents as young people between the age of 10 and 19 years, and they constitute about a sixth of the world's population and about 36.7 percent of Zambias population [2]. Adolescence has been described as a time when young people engage in increased risk-taking behaviour that exposes them to many health risks. Adolescent sexual and reproductive health (ASRH) is a global public health concern.

This is because sexual activity of adolescents has been on the increase in many countries around the world. However, globally, adolescents access health services less frequently than expected because of the various challenges in accessing reproductive health services (RHS) [3]. In addition, adolescents are poorly informed about how to protect themselves from pregnancies and sexually transmitted infections (STIs). Regional differences exist with adolescents in developing countries experiencing greater challenges [4]. Research has shown that in many countries in sub-Saharan Africa (SSA), young people face significant barriers to receiving ASRH services resulting in the under utilisation of these services.

Adolescent sexuality and reproductive health has become a global concern in the recent past. The concern has grown due to unprecedented increasing rates of sexual activity, early pregnancies, and sexually transmitted infections (STIs) including human immune deficiency virus (HIV) among adolescents [5].

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Adolescence is a time of great change for young people when physical changes are happening at an accelerated rate [6]. Research shows that many adolescents become sexually active before the age of twenty [21].

As a result, they require a wide range of counseling, clinical, and preventive care. Research further shows that adolescents face challenges in accessing reproductive health services leading to them seeking the services after sexual exposure [7, 20].

Not unlike adolescents everywhere, most Zambian adolescents are sexually active by their mid-teens. The Zambia Demographic and Health Survey [8] reported that among women and men aged 15-19, 13% of women and 16% of men have sexual intercourse by age 15. Only 2% of women and less than 1% of men aged 15-19 are married by age 15. Two percent of women aged 15-19 give birth before age 15, and less than 1% of men in that age group father a child before age 15.

Several efforts have been made, at both national and sector levels, aimed at protecting children and adolescents, and improving their health status. However, there are still weaknesses and gaps which need to be addressed, to improve adolescent health in Zambia. These gaps are found at all levels, including policy, legislation, planning, financing, implementation, and monitoring and evaluation levels. It is for this reason that we have prioritized adolescent health in the National Health Strategic Plan 2011 to 2015 (NHSP 2011-2015) and have developed this strategic plan [9].

UNFPA (2019) points out that [2] adolescent girls in particular face numerous development challenges that limit their access to opportunities for good health, education, and employment, among other things. As Zambia advances in domesticating the expansive and complex Sustainable Development Goals, it is critical to address these issues.

By doing this, Zambia would be securing and utilizing the window of opportunity, which is time-limited, to utilize a "demographic dividend" in coming years. The potential economic gain that can happen when a county's educated, skilled, and healthy working-age population is greater than its dependent community is known as the demographic dividend. (i.e., younger or elderly).

To fully understand the levels and types of targeted investments made by all player's, sustained effort is also needed to produce, analyze, and use national development data that is broken down by factors such as age, gender, and income levels. The government through the Ministry of Health and its partners is making several efforts to discourage adolescents from engaging in early sexual activities and to encourage them to seek health services. However, adolescents have continued to face several health issues. The main health-related problems facing the adolescents in Zambia like those of Chingola District, include common health problems, including communicable and NCDs; and behaviour related health problems, including early and unprotected sex, sexual abuse, early marriages and pregnancies, unsafe abortions, drugs and alcohol abuse, trauma/accidents and violence, and unsafe cultural practices [10, 11].

Zambia has a high disease burden. Whilst the various health problems are common to the general population, largely due to stigmatization, health problems such as HIV and AIDS, and STIs present special challenges to adolescents, calling or special attention. In addition, a study by [12] found that in most of the situations, the adolescents tend to shy from seeking health services, stigmatization is also common for those seeking help while others tend not to know that information on adolescents' health is made available in health centres and schools.

Methods

Study Design

An exploratory descriptive design was used for this study and was appropriate for

understanding in greater depth the factors associated with accessibility and utilization of adolescent health services in Chingola [15].

Setting

The study was carried out in four government secondary schools and one health institution in Chingola District from November 2022 to January 2023.

Participants Selection

The participants of the study were ten (10) male and ten (10) female adolescents who were of the age 15 to 19 years. In addition, they attended the specified school and attended health services at the named health facility. Also, five (5) RHS providers were purposively selected based on the health centre being near to the school.

Data Collection

Data collection methods included individual semi-structured individual interviews with adolescents and the RHS providers. All interviews were conducted by the principal researcher after discussing the study protocols with eligible participants in private rooms. Interview guides were used for interviews which consisted of open-ended questions covering adolescents' knowledge of and perceptions about RHS, their experiences with the RHS offered and the barriers encountered.

Data Analysis

Thematic analysis was used to analyze the transcribed data, which involved familiarizing oneself with the data, creating initial codes, looking for themes, reviewing themes, and defining and labeling themes [16-17]. The transcriptions and first codes created by the lead researcher were distributed to the other team members for validation.

Ethical Considerations

The respondents were explained to in detail the nature and purpose of the research prior to the research. In addition, for adolescents under 18 years, permission to interview them was obtained from their parents while consent was obtained from those 18 to 19 years. Further, no respondent was influenced to answer in a particular way.

Results

Profile of the Respondents

Table 1 illustrates the responses pertaining to the respondents' profile. The table shows that 10 (50 percent) of the adolescent respondents were male and 10 (50 percent) were female. With regards to the age group, 2 (10 percent) were 15 years, 5 (25 percent) were 16 years and 4 (20 percent) were 17 years. In addition, 4 (20 percent) were 18 years and 5 (25 percent) were 19 years.

Table 1. Profile for the Adolescent Respondents

Variable	Description	Frequency	Percentage
Gender	Male	10	50.0
	Female	10	50.0
Age group	15 years	2	10.0
	16 years	5	25.0
	17 years	4	20.0
	18 years	4	20.0
	19 years and above	5	25.0
Grade	8	2	10.0
	9	3	15.0
	10	5	25.0
	11	4	20.0
	12	6	30.0

For the grade, 2 (10 percent) were in grade 8, 3 (15 percent) were in grade 9 and 5 (25 percent) were in grade 10. In addition, 4 (20 percent) were in grade 11 and 6 (30 percent) were in grade 12.

Table 2. Profile for the RHS Provider Respondents

Variable	Description	Frequency	Percentage
Gender	Male	2	40
	Female	3	60
Age group	18-25 years	1	20
	26-33 years	2	40
	34-41 years	1	20
	42-49 years	1	20
Education level	College certificate	1	20
	Diploma	2	40
	University degree	1	20
	Post graduate degree	1	20
Years of working as a RHS provider	Less than a year	1	20
	1-4 years	1	20
	5-9 years	2	40
	10 years more	1	20

Findings

Stigmatization was identified to be one of the major the factors associated with accessibility and utilization of adolescent health services in Chingola, Zambia. One of the adolescent respondent indicated that "*it come a problem when your classmates get to know that you went to seek reproductive health services from a health Centre."*

The other respondent pointed out that "*when I went at the clinic to find out more on RHS, I met some classmates who were seeking medical attention in the OPD. The following day, news was all over that I went in the reproductive health office at the hospital. The days that followed, the other learners started teasing me and calling me all kinds of names.*"

The other factors can be associated with a lack of sufficient education as the learners are not fully informed on the various health services that they can access from the health Centre. For instance, one of the respondents pointed out that "*I never knew that you can access information of various health matters from the clinic. I thought, one can only visit the clinic when they are sick to get medication."*

The findings also show that there is no linkage and referral system between the schools and the health facilities for adolescent health services. Adolescents need to be made aware of the services offered in health facilities. Those aware cannot visit the facilities because of distance to and from, the stigma of visiting the facilities from fellow students and the community, and inconvenient operating hours by the facilities, which makes them not leave classes.

The adolescents also indicated that they lack support from their parents, who are unaware of the services, and those aware have wrong views about them. It was also highlighted that the providers have a terrible attitude as they are deemed unfriendly and intimidating to adolescents.

Respondents Proposed Solutions

Introduction of Solution

The proposed solutions will help to improve the utilization of adolescent health services which in turn will help reduce adolescent health

issues and reduce the burden on public health. The following are the solutions.

1. To establish and strengthen the linkage between the schools and health facilities adolescent health services through collaboration of activities for the two institutions, activities like drama groups, outreach, and calendar of activities.
2. To create awareness by sharing information to the adolescents during the school assemblies, school games and school open days when both the parents and the students meet in schools.
3. The services to be provided during weekends and any other free time to attract more adolescents to access without being inconvenienced and the schools to come up with deliberate policy to allow them to visit the facilities whenever necessary with a referral slip from the schools.

Application of the Solutions

The following are deemed to be the application of the solution:

Provider/School level

1. The providers of the services meet with the school administrators/teachers to discuss the best way of how the schools can be linked to the facilities near them for easy access.
2. Health providers to involve adolescents in catchment schools in activities like peer education and drama groups.
3. The providers conduct outreach to the schools to take the services offered to the adolescents in schools.
4. The school or invited provider to give sensitization to the parents on adolescent health during open days at schools and to give talks to the adolescents during assemblies.
5. The adolescent health providers improve their attitude towards the adolescents to avoid prejudice and stigma, also the providers to be of average age to allow the adolescents free expression.
6. Private sector/NGOs are present in the district to facilitate the linkage and networking with the schools and health facilities offering the adolescent health services.

Community Level

1. To create community awareness through gatherings, radio programs, posters and by involvement of the community in the activities of adolescent health.
2. Private sectors and NGOs to come up with community-based programmes and activities in adolescent health.
3. Involving community leaders and parents in the decisions regarding adolescent health care.
4. Effective approaches should be implemented to enhance community acceptance of adolescent health programmes.

Policy Level

School administrators formulate flexible rules to allow adolescents to visit the facilities with a referral slip where the feedback to school will be provided by the provider.

Long Term Focus

The adolescents are expected to grow and develop in good health hence they need information, including age-appropriate comprehensive sexuality education, opportunities to develop life skills, health services that are acceptable, equitable, appropriate, and effective and safe and supportive environments.

Conclusion

Improving the utilization of adolescent health services is a global dream. This dream can be realized only if the efforts are made to reach the adolescent population. The purpose of this paper was to explore the factors associated with accessibility and utilization of adolescent health services. It was found that adolescents encountered negative attitudes from the service

providers, lack of support from the facilities, lack of awareness and education of the services provided. Prior studies found fear, stigma, shame, and luck of information as major factors to accessibility and utilization of adolescent friendly health care in Zambia, Vanuatu, and South Africa. This paper provides useful proposed solutions for health policy makers and practitioners, especially those directly responsible for adolescent health.

Recommendations

1. Clinics and health centres should take advantage of technology and use electronic means to increase awareness of available reproductive health services for adolescents. For instance, they ought to make social groups on social media aimed at reaching out the adolescents.
2. The Clinics and health centres should have door to door programs for the community aimed at sensitizing adolescents about reproductive health.
3. Clinics and health centres through the Ministry of Health should scale up adolescent-friendly services to meet the needs of both boys and girls.
4. Clinics and health centres through the Ministry of Health should use mobile services to provide services to address the problem of distance boys and girls cover to the nearest health facility.
5. The Ministry of Health to have regular training and in-servicing of health service providers to effectively serve adolescents with emphasis on adolescents' rights to confidential and comprehensive reproductive health services.
6. More NGOs should be encouraged to incorporate adolescents in their programs. For instance, DREAMS has been at the center of adolescent health advocacy, as such other organizations should be encouraged to follow the path for dreams.

Conflict of Interest

The authors declare that they have no conflict of interest.

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Secondary School Students' Mathematics Anxiety: A Zimbabwean Perspective

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Abstract

This study employed a mixed-methods technique to examine the spectrum of mathematics anxiety levels felt and expressed by Zimbabwean students studying Ordinary level mathematics. Ninety-one pupils from forms 3 and 4 (N = 91) made up the convenient sample; of them, 41 were male and 50 were female. The instrument used was the Hopko-adapted amalgamated mathematics anxiety scale (aMAS) (2003). While focus group conversations were audio recorded and transcribed to explore in-depth, social settings and learning environments that cause anxiety, the quantitative data was analysed using SPSS, version 23.0. The key categories were then thematically classified and analysed with quantitative information. To test a hypothesis based on the data, an independent samples t-test was run to see whether males and females' anxiety levels differed by mean. The results showed that the participants experienced significant mathematics anxiety, and many situations—including parental and social pressure, instructional methods, and learning environments—reinforce math fear. Findings also show that, society exerts significant pressure on learners due to high expectations of success in mathematics. Additionally, some teachers were viewed as fuelling the anxiety through their repertoire and that classroom environments may unintentionally cause discomfort to mathematically challenge peers. Interesting suggestions were made by respondents regarding how to help people with math anxiety. The study offers a compelling case for its relevance to teacher education, research, and instructional practice. The study also recommends conducting comparative studies as one method of comprehending the issue.

Keywords*: Cognitive achievement, Mathematics-anxiety, Teaching-learning, Gender issues, Social phenomena.*

Introduction

The general problem of interest is the issue of Mathematics Anxiety (MA) in the secondary school context in Zimbabwe. Math is a necessary skill not only for academic success but also for effective everyday living. Hembree and Ashcraft, posited in [1, 2] that when confronted with numerical challenges, however, a considerable section of the population feels anxiety and trepidation. This negative emotional reaction to math is formally called "Mathematics anxiety" (MA), and it has also been shown by Carey et al in [3] to interfere with mathematics performance as well as lead to people avoiding it altogether. Mathematics anxiety is defined by Cemen in [4] as a feeling of unease experienced by students when asked to execute mathematical tasks. Further, Suinn and Winston, in [5] added that when dealing with mathematical assignments, the salient manifestations are a feeling of discomfort, which includes hate of the subject, worry, and fear, as well as specific behavioural manifestations such as tension, impatience, despair, helplessness, and mental disorganisation.

Also, Ashcraft, Dew et al and Zakaria in [2, 6, 7] confirm that when confronted with mathematics stimuli, individuals experience

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elevated physiological sensitivity, negative cognitions and anxiety in Mathematics is a psychological aspect of learning that educators must recognise.

Literature Review

Mathematics anxiety has long been thought of and assessed as a multidimensional construct by researchers such as Liebert and Morris and Wigfield and Meece in [8 & 9]. Emotionality, which is the physiological aspect of anxiety (e.g., palms sweating, heart racing), and worry, which is the cognitive aspect of anxiety (e.g., worried thoughts, racing heart), are two ways to think about it.

On the other hand, Alzahrani in [10] opines that students' social circumstances, cognitive functioning, and academic ability vary, all of which can be linked to varied degrees of Mathematics anxiety. Further, they assert that social variables, such as parental and familial support, could be an important factor influencing one's perception of mathematics and, as a result, associated anxiety when studying the subject, particularly in households with low socioeconomic status and that students with low self-esteem and a lack of drive to learn mathematics may be more concerned about their grades. In [11] Mutodi and Ngirande, also postulated that many pupils who experience MA never previously built strong foundations in basic mathematics. Because mathematics is an accumulative subject, complex concepts are built on a base of simpler concepts, and a student who lacks a sound arithmetic foundation will struggle to acquire higher-level math.

Another important consideration by Ruff and Boes in [12], is that learning and retention of learned mathematics concepts, cognitive functioning ability, combined with a lack of understanding of some concepts when first taught, as a result of personal learning difficulties or a lack of ability to focus, particularly for younger students, can contribute to one's anxiety when it comes to the learning of mathematics.

Elsewhere, Hembree, Rollinson in [1, 13] have established that highly math-anxious students tend to participate less in lessons and perceive their mathematical skills as sub-standard and are less likely to pursue math-related courses and that MA results in reduced cognitive reflection.

Moreover, Arem in [14] confirms that MA stems from unpleasant past experiences with mathematics, which agrees partly with Denhere in [15] in as far as past experiences are concerned. Arem, further asserts in [14] that pupils who have a high level of mathematics anxiety have negative thoughts about their abilities and will have a difficult time working with numbers and mathematical concepts in problem-solving situations. This is in agreement with Zakaria in [7], who concluded that pupils who perform well in mathematics have a favourable attitude toward the subject.

Other factors include cognitive predisposition as posited by Lyons and Beilock in [16], Young and Wun in [17], sociocultural gender stereotypes and negative self-talk, social pressure, and the expectation to attain great achievements, the drive to excel, myths about math study, and negative self-perception.

One of the most difficult aspects of gauging Mathematics anxiety is the impact that society has on pupils' perceptions of Mathematics. In a study in [18] which examined the association between Mathematics anxiety and social desirability, Zettle and Houghton, discovered that college-age males are less likely than females to report emotions of anxiety regarding mathematics because men believe it is socially unacceptable for men to have such feelings.

Others have found that Mathematics anxiety is a strong predictor of mathematics performance in both male and female pupils e.g., Kytala and Bjorn in [19] while females exhibit more Mathematics anxiety than males, according to Khatoon and Mahmoud in [20] and have proffered suggestions to motivate and encourage female pupils to learn mathematics by focusing on changing the classroom environment and

ecology. Further, female students are frequently characterised as shy, which can hinder their capacity to learn. Khatoon and Mahmoud in [20] ascertain that male students are more active in a wider range of social activities than female students. The data on gender disparities in MA varies with culture, age group, and study. Females (including adults and children) have greater MA than males, according to the majority of studies. For example, in the United States, Hembree in [1], Dove, Montague and Hunt, [21] in the United Kingdom, Spain, Núñez-Peña et al, in [22], and Poland, Cipora et al in [23].

In contrast, in [11], Mutodi and Ngirande, explored students' Mathematics anxiety levels at a selected tertiary institution in South Africa, female students were found to have a higher incidence of Mathematics anxiety somehow which confirmed previous findings by Cipora et al in [23], such differences (i.e., women revealing higher levels than men) have been reported. In another study in Qatar, (a culturally different environment) Zahrani in [7] found that there were no statistically significant differences between male and female students' Mathematics anxiety in contradiction with the findings of [20] in Khatoon and Mahmood.

Moreover, according to Furny and Duffy in [24] poor test scores, inability (or desire) to finish tough assignments, negative parental attitudes, and even the mathematics teacher can all contribute to math anxiety. Teachers and parents who are terrified of mathematics pass this fear on to their children and students.

Parental influence, according to Dove et al, Maloney and Haimowvitz and Dweck in [21, 25, 26], may mediate the development of arithmetic anxiety and have a major impact on children's performance. These include parental worries or insecurity about Mathematics, which can lead to unfavourable bias in children and the formation of preconceived notions about math as a difficult learning area. Also, high or unrealistic parental expectations of their children's mathematics talents or achievements might impact feelings of Mathematics anxiety and dread of failure.

Meanwhile, a student's impression of mathematics may be influenced by the teaching methods utilised and the teacher's personality. Academic elements such as the usage of traditional teaching approaches, as well as teachers who have inherent fears with teaching and/or the associated presentation of a particular topic, may influence students' anxiety when learning mathematics concepts.

In addition, teachers may be perceived as unwilling to provide extra support to students who require it and may be viewed as uncaring. When his/her students do not grasp the issues, the teacher may become enraged or upset as well as having unrealistic expectations for his/her students or an inflexible repertoire.

It is also a strongly held view, e.g., Furny and Duffy in [24], that students may become discouraged from learning mathematics if they are forced to go through the textbook question by question. Giving pupils written work every day, emphasising that there is only one correct way to solve a problem, and assigning mathematical problems as a punishment for misconduct can all make children detest math.

However, it is also widely expected that teachers can play a significant role in recognising mathematics anxiety in their students early in their education and adopt strategies to help them overcome their fears as suggested in [7] by Zakaria. Some experts also believe that bad classroom experiences are enablers in the development of an arithmetic phobia. Dove et al in [21] suggest that this can involve Mathematics being taught in a rigorous, non-interactive, or rote manner without a complete unpacking of the concepts and procedural knowledge, or an over-reliance on exams to assess math learning and as well as teacher attitudes. Meanwhile, Maloney and Haimowvitz and Clack, in [25, 27] indicate that a person's ability to use working memory is significantly reduced when they are under stress when performing math, which inhibits them

from coming up with the answers to questions they could normally think of.

There have been some suggestions on how to help pupils overcome mathematics anxiety. These include amongst others, pupils assessing their learning without their friends knowing their score, of which anonymous online tests and exercises can be assigned on appropriate online learning management systems (LMS) if such conditions are existent. Further, Marshall et al in [28] stated that pupils can have access to core learning materials ahead of time and use contact time to focus on processing and applying what they've learned i.e., the flipped learning model. These suggestions may not be a one size fits all remedy given the variety of circumstances and contexts of learning environments in Zimbabwe.

In Zimbabwe there are currently not many significant studies on mathematical anxiety and of these, the salient one was that carried out by Mutodi and Ngirande in [11]. The study, which focused on examination or assessment anxiety, was conducted in four secondary schools.

The results indicated that the majority of students (90 percent) suffered from mild to severe anxiety, sadness, and stress. Females were found to be more stressed during examination periods than males.

In a related study, Denhere in [15], explored the possible causes of mathematics anxiety in Zimbabwe, albeit on a small scale, as identified by form three students. The general conclusions included:

'Mathematisation of the curriculum; negative traditional beliefs/philosophies; defective genetic make-up; embarrassing mathematical experiences; eclecticism and hostile learning environments among others.

Interestingly, Mandinda and Mashingaidze in [29] studied the approaches to enhancing female involvement in Mathematics at advanced level (A level) in Zimbabwe schools in terms of the constraints to female participation in mathematics. Mathematics anxiety was found to be a crucial factor in determining their pursuance of Science, Technology, Engineering and Mathematics (STEM), courses post-secondary. This confirms, amongst other assertions that MA has crucial implications for the posterior development of students' attitudes, as apparently, it is fairly stable over longer periods, as stated by Primi et al in [30].

Students throughout the world experience Mathematics anxiety regularly. According to Alzahrani in [10], students are unable to pursue their studies in mathematics and associated science disciplines at the postsecondary level because of the high levels of anxiety they encounter in classrooms.

Although these studies may well have had good intentions, they did not report students' perspectives on the triggers of MA and how in their words, these triggers could be ameliorated. Another aspect is that most of the research has been done in European contexts and has largely been quantitative without the inclusion of participants' perspectives to give more context to this issue. This study hoped to add to the body of knowledge in the Zimbabwean context, hence it is important to recognise, debunk, and lessen the anxieties associated with the teaching and learning of Mathematics in Zimbabwean classrooms if we want to increase the number of students pursuing STEM fields at the secondary and tertiary levels. The results could also be used to identify and minimise the practices that reinforce Mathematics anxiety and involve all stakeholders in an ongoing conversation that should have a positive effect on the teaching and learning of mathematics. This may help create sensitive and approachable learning activities and materials for curriculum materials developers and teacher educators.

Research Questions

The study was guided by the following research questions:

1. What are the levels of prevalence of Mathematics anxiety in adolescent students in selected Zimbabwean schools?

2. What situations trigger anxiety in Mathematics teaching and learning environments in adolescents?
3. How can students be assisted in mitigating the effects of Mathematics anxiety?
4. Is there a statistically significant relationship between Mathematics anxiety and gender in adolescent students?

Participants

The participants were a convenient sample of ninety-one students, from three urban schools in Zimbabwe. The first year of the two-year Ordinary level program is Form 3, whereas Form 4 is the second and final year. After receiving grades of C to A in their external exams, students would then continue to study A-level subjects of their choosing. To access mathematics, the participants use English as a second language.

Methods

A mixed techniques approach was used and according to Taylor and Fraser in [31], this approach enables data triangulation, which is essential for assuring research validity. A modified informed consent form World Health Organisation (WHO) in [32], was given to pupils for parental permission, and the researcher obtained approval from the relevant authorities, including the Ministry of Education. To maintain their anonymity, the students who took the survey did not indicate their names or form classes. The research employed an adapted mathematical anxiety scale (aMAS), developed by Hopko and in [20, 33]. The aMAS contains 13 statements that describe scenarios when high school pupils are exposed to mathematics. Students were asked to rate their level of anxiety in several scenarios on a 5-point Likert scale, with "strongly disagree" is the least worried and "strongly agree" being the most nervous. Three major constructs—general anxiety, cognitive/learning anxiety, and assessment anxiety—have been separated out for the purposes of this study's consideration of mathematics anxiety.

To determine the range of mathematical anxiety levels among students and the association between mathematics anxiety levels and their gender, an independent samples t-test was conducted. Using SPSS software, descriptive and inferential analyses were carried out. The last step involved a focus group interview in which willing participants were asked about their experiences with MA in classroom settings.

The preliminary scale was readability tested with a different set of students, construct validity was verified by knowledgeable colleagues in the mathematics department, and tweaks were made to make the questions more succinct and straightforward. The degree to which all test items assess the same attribute is shown by Cronbach's alpha coefficient, which according to Huysamen in [34], measures internal consistency. The scale's Cronbach coefficient, which was 0.783, was deemed appropriate.

Findings and Discussion

The research participants responded to the survey with a good response rate. A total of 91 completed questionnaires were in hand after the data-gathering period. An 83 percent response rate was achieved given that the study's sample size was 110.

Table 1. Demographic Variables of Participants

Variable	Frequency	%
Gender	Male 41	45.1
	Female 50	54.9
Form	Form 3 53	58.2
	Form 4 38	41.8
Home Language	Isindebele 71	78.0
	Shona 19	20.9
	Other 1	1.1

The Table 1 that the sample comprised more females than males. The participants spoke a variety of native tongues. These form part of the 16 official languages spoken in Zimbabwe. Only one pupil had a distinct native tongue. It is important to stress that from a linguistic standpoint, all participants approach mathematics from the same position as English as a second language learners.

The first research question's aim was to examine the range of mathematics anxiety levels felt and reported by students in Zimbabwe who were studying high school Mathematics. The fact that students displayed a range of worries at various levels suggested that there was a broad sense of unease or general anxiety among the participants.

Table 2. Use of Mathematics in Higher Education

I believe I will handle Maths in my career					
Response		**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**SA**	28	30.8	31.5	31.5
	A	40	44.0	44.9	76.4
	DA	6	6.6	6.7	83.1
	SD	3	3.3	3.4	86.5
	Neutral	12	13.2	13.5	100.0

Table 2 shows that most participants believed they might succeed in math in higher education, although a minority (10.0 %) voiced grave concerns about continuing with the subject.

Table 3. Mathematics Preference in Higher Education

I prefer Maths in Higher Studies					
Response		**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**SA**	32	35.2	35.2	35.2
	AG	34	37.4	37.4	72.5
	DA	12	13.2	13.2	85.7
	SD	4	4.4	4.4	90.1
	N	9	9.9	9.9	100.0

Table 3 interestingly shows that, more participants claimed they intended to use math in their future schooling, while just 17.8% expressed scepticism about their intentions.

This shows that failure is a primary threat in Mathematics Anxiety and suggests that expectations of failure are immediately and automatically activated in highly mathematics-anxious individuals. This may also be a sign of the enormous societal pressure placed on math achievement as a prerequisite for admission to STEM courses and individuals who did not envision a future with Mathematics felt gloomy.

Table 4. Future Prospects of Engaging with Mathematics

I would like my future career to involve maths					
Response		**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**SA**	11	12.1	12.1	12.1
	AG	26	28.6	28.6	40.7
	DA	27	29.7	29.7	70.3
	SD	9	9.9	9.9	80.2
	N	18	19.8	19.8	100.0
	Total	91	100.0	100.0	

Additionally, more students indicated that they would be open to employing Mathematics in their careers, whereas 17.6% strongly opposed it. This suggests that there is a critical mass of participants who might be affected by greater levels of worry. Further analyses showed that, 42 students (46.20%) indicated that they were afraid to ask questions during mathematics lessons, which is an indicator of cognitive/learning anxiety in other participants additionally, 17 students (19, 30%) indicated they did not like their mathematics classes at all. Many reasons can be attributed to such an attitude, for example, bad classroom experiences amongst many others as posited by Dove et al in [21].

Table 5. Feelings about Mathematics Homework and Support

Working on Math's homework stresses me out					
Response		**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**SA**	18	19.8	19.8	19.8
	AG	17	18.7	18.7	38.5
	DA	22	24.2	24.2	62.6
	SD	18	19.8	19.8	82.4
	N	16	17.6	17.6	100.0

Table 5 shows that a good proportion of students reported feeling upset and unassisted in extension work i.e., homework while a critical mass of 16 (17, 6%) were unconcerned. This suggests that teachers must come up with creative ways to help students outside of the classroom when they need it.

The flipped classroom is an ideal solution to enhance interaction if technology allows it. In the flipped classroom model, learners are assigned tasks that they perform outside school time, usually online and then revision is done during lessons mainly focussing on challenges faced while working on the concepts embedded in the task.

Table 6. Assessment Anxiety

I get tense when preparing for a mathematics test					
Response		**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**SA**	17	18.7	18.9	18.9
	AG	32	35.2	35.6	54.4
	DA	22	24.2	24.4	78.9
	SD	10	11.0	11.1	90.0
	N	9	9.9	10.0	100.0

Furthermore, as shown in Table 2.5, there was a significant amount of assessment anxiety, with as many as 40% of the students worrying about their exam outcomes and only 20% not caring. 49 people (54, 40%) expressed concern about their academic performance as they said they were nervous before a mathematics test. This supports the common experiences of worry among participants over their ability to succeed in Mathematics.

In contrast to the 38 participants (42%) who found it challenging to complete the mathematics exercises, only 37.7% of participants felt at ease and 47.80% lacked the confidence to ask questions in class. On the other hand, 62 individuals (68%) expressed fear of giving a false response in front of the class. This is further buttressed by the fact that when the teacher explained, 29 (29, 7%) pupils indicated

they felt under pressure, whereas 50 (55, 00%) disagreed.

Teachers were accused of exhibiting unintentional eclectism which invariably leads to more confusion with students. This agrees with the findings by Denhere in [15] and Mutodi and Ngirande in [10]. Moreover, these results are in line in principle with the findings of Hembree, Zakaria and Arem in [1, 7, 14], who all agreed that students who experience high levels of Mathematics anxiety have low opinions of their talents.

These findings highlight the value of creating a respectful, pain-free, and tolerant learning environment. Students must be encouraged by their teachers to support one another and refrain from passing unsolicited judgment on one another throughout the lessons.

To make sense of the quantitative results, focus groups interviews were held as part of the study, and willing participants gave their opinions about the prevalence of MA, anxiety-provoking scenarios in the classroom, and ways that, in their opinion, may be used to lessen the detrimental impact of Mathematics anxiety.

On a scale of 1 to 10, with 10 representing the most uneasy, students were asked to rate their feelings of anxiety. The findings indicated that 40% of the individuals had different types of anxiety on varying measures that inclined toward uneasiness. This points to an observation by Dowker and Sheridan in [35] that the incidence of Mathematics anxiety will vary on the sample's makeup and the definition used, but even the lower figures indicate that it is a substantial issue for many.

The second research question sought to ascertain what situations trigger anxiety in mathematics teaching and learning environments in adolescents? Students who were asked to describe the nature of their fears expressed anxiety before tests which appeared in feelings of dissatisfaction, "we do not know what will be on the test," shivering, sweaty palms, feeling terrified, forgetfulness, and worry about passing the test, afterward.

Participants who were asked to name anxiety triggers mentioned a variety of situations, including pressure from parents (27, 0%), teacher practices and expectations, as well as peer pressure in learning environments- being laughed at when one makes mistakes, being mocked, and feeling isolated to the point where they used "keeping up the appearances even if one does not understand", as a coping mechanism.

Some teachers reportedly began lessons without outlining the lesson's goals repeatedly, sometimes failed to simplify the material, yet held pupils to a high standard, and covered the material rapidly (this point was applauded by many).

Teachers have occasionally been seen to be unhelpful when asked for assistance, prompting the question, "how can you not understand when others do?' This expression was mentioned frequently by the participants. Students believed that math instructors overlooked student differences in their instruction as they seemed to be preoccupied with syllabus completion.

The settings in the classroom can be created to support a growth mind-set and lessen the stress felt by mathematics students. Students' overall mind-sets can be altered by implementing techniques that encourage them to focus on mastery rather than getting all the answers correct and to view failure as a chance to learn.

Further, teachers must also consider using a variety of techniques that accommodate the individual peculiarities of each student and take their time when covering material. Simply put, teaching should be differentiated, i.e., address individual differences and this involves careful planning by the teacher as the facilitator.

The use of active learning activities that bring 'fun' to the subject is imperative. This could be in the form of graphic organisers, think-pair-share, traffic lights, exit passes, hot chair strategies, and group work among many within the Assessment for Learning (AFL) paradigm. Assessment of learning, (AOL), which is

essentially summative assessment, should then be viewed as an opportunity to assess progress by both teacher and student in view of previously set targets and addressing the limitations identified in the assessment.

One strategy could be promoting discussion and allowing for the exchange of ideas as Clark in [27], adds to this idea by confirming that a crucial step in ensuring that student groups offer each other no misconceptions is debriefing, i.e., teacher interrogation, to assess the smaller group's thinking. Additionally, students stated, educators need to create a safe learning environment where respect is valued. When teachers make fun of students, when they don't understand the material, when they attain poor test grades and the results are made public or when they demonstrate that they don't understand the concept and are still asked to go to the board, when they don't know the answer when asked, and in other similar situations, peer pressure causes anxiety (afraid of saying wrong answer- peers laughing).

This also confirms the assertion by Clark in [27] that individuals may already know the answers to problems but worry prevents them from accessing that portion of the brain (working memory), making it impossible for them to find a solution at that time. An individual may begin to experience Mathematics anxiety if bad performance leads to more anxiety, which in turn leads to poor performance. This vicious cycle might lead to the conclusion that one is simply not good at arithmetic, and trigger Mathematics anxiety.

In addition, parental influence as discussed in Haimowvitz and Dweck in [26] was singled out as a significant source of pressure where parents desire excellent performance yet is unwilling to provide support, emotionally, physiologically, and financially for their children. The parent's impression of failure is more closely related to the child's thinking than it is to that of the parent. Parents who saw failure as a crippling event in their child's academic career led to their children believing intellect was fixed.

The third research question sought to identify how students felt they could be assisted to overcome MA. Participants said they would value it if parents helped them become more self-assured and encouraged them to persevere. Schools would need to assess how parents may be assisted in that regard.

Students knew what they needed to do in order to be proactive when asked what they could do to minimise MA. They stated that they had to efficiently manage their time, pay attention, practice frequently, evaluate themselves, and actively participate in lessons. Subject teachers could help students set smart targets in their journals as well as constantly sharing the success criteria for most if not all learning and assessment activities. Student must know what the content and skills of their assessment(s) will be:

Students added that they needed to follow up on lessons, "keep their eyes on the ball," and ask for help early, before significant exams. This is a positive growth mind-set, as there aren't any individuals who are better suited to learn mathematics; rather, only those who are more open-minded, receptive, and confident in their ability to do so.

Another point mentioned by the students was that, on occasion, it was impractical to ask for help from siblings and parents who might have forgotten the material due to the passage of time. According to Clark as discussed in [25], there is some truth to the claim that, if parents with MA frequently help their children with their homework, the amount of math a student learns over a school year may decrease.

Nonetheless, the participants had valuable counsel for teachers. They implored teachers to design stimulating, contextualised classes, filled with concepts and examples from real life and at the same time, be diagnostic, patient, and encouraging. This supports the research by Mutodi and Ngirande in [11], who posited that traditional methods of teaching mathematics were a major cause of worry for many students.

The fourth research question attempted to determine whether there were significant differences in mean scores between math anxiety levels and gender. An independent-samples t-test was conducted to compare the anxiety level differences in scores for males (M= 16.15, SD = 2.21) and females (M=15.75, SD = 2.19; t (85) = -849, p=0,389, two-tailed). It was concluded that there were no significant differences between gender and the levels of anxiety, p>0.05.

This result contrasts with those of the majority of studies conducted in some European societies, where female students are frequently perceived as shy, hence suffered more from MA, Hembree, Núñez-Peña et al, Cipora et al a Hunt et al in [1 ,22,23, 36]. However, in [11], Mutodi and Ngirande observed that females were more nervous than males in that Zimbabwean context.

Conclusion

To ascertain whether gender and the students' degree of mathematics anxiety were related, the research looked into the range of mathematics anxiety levels experienced and expressed by Zimbabwean pupils studying ordinary-level mathematics. The findings suggest that MA is a learned behaviour that transcends age, culture, and language.

The study concludes that a significant number of Zimbabwean adolescent students experience mathematics anxiety as a result of several circumstances. Students also claim that a range of variables contributes to mathematics fear, including — parents, society, learning settings, and instructional methods. By having high expectations for mathematics performance, parents can unintentionally or intentionally contribute to anxiety reinforcement. Students are under needless pressure, which causes worry.

Additionally, students suggested that teachers could think about including a variety of active learning strategies, differentiate their instruction, and structure lessons following the social constructivism paradigm. The classroom environment can be designed to foster a growth mind-set. Techniques that encourage students to place more on mastery and view failure as an opportunity to learn can change the way they think about learning in general. Finally, the students' level of math anxiety was unrelated to their gender in this sample of students.

Implications and Recommendations for Further Study

The findings of this study have implications for different stakeholders. The control of the learning environment and ecology could be promoted among teachers. Students demand a fun and emotionally secure learning environment. When planning lessons, it's imperative to take a bird's-eye view of all the participants and consider the alignment of the following factors: classroom expectations, learning objectives, success criteria, learning activities and differentiation, materials, assessment, and feedback. For successful outcomes, these should be in alignment.

Furthermore, by having a discussion about the topic and offering school courses on learning issues before parent meetings, schools can address the parental impact on MA. This offers an opportunity for discussion about such educational obstacles as MA.

Teachers could be surveyed to determine how they approach anxiety and gauge their understanding of and awareness of their instruction in larger and comparative studies. The design of relevant pre-service and professional development opportunities would then be based on such findings. Mathematics teacher education could also explore ways of promoting awareness of Mathematics anxiety in the curriculum.

Conflict of Interest Statement

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Dental Pulp Stem Cells in Regenerative Therapy

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Abstract

Stem cells, also known as progenitor/precursor cells, have the unique trait of self-renewal and multi-lineage differentiation. Dental stem cells (DSCs) are holding a pivotal role during recent times as they thrive as the cornerstone for the development of cell transplantation therapies that correct periodontal disorders and damaged dentin. DSCs are used therapeutically for different organ systems and numerous diseases, including neurological disorders, diabetes, liver disease, bone tissue engineering, and dentistry. In dentistry, the focus is on predominantly regenerating the pulp and damaged dentin, repairing perforations, and periodontal regenerations. Above all, whole tooth regeneration has been constantly under research. The next decade could be a crucial junction where huge leaps in stem cell-based regenerative therapies could become a reality with successful tissue engineering therapies this could be a biological alternative to synthetic materials that are in use currently. But dental stem cells have their share of challenges for which the research must happen effectively adhering to social responsibilities at all levels.

Keywords: *Stem cells, Regeneration, Regenerative therapy, SHED.*

Introduction

The human teeth are composed of specific tissues, including the outer mineralized enamel, the dentinal layer adjacent to it, the dental pulp consisting of blood vessels, mesenchymal tissue, and nerves, and the root structure containing the dentin, cementum, and periodontal ligament (PDL) that assist in anchoring the teeth to the alveolar bone [1]. Every organ in the human body originates from the human germ, and the tooth is no different. It's the number of tooth germs formed during the embryonic stage that determines the total number of teeth in an individual [2]. Human tooth formation is the result of the integration of spatiotemporal cellular responses, including proliferation, apoptosis, differentiation, movement, and polarization. Hence, by monitoring the process of cytodifferentiation and organogenesis, there are umpteen possibilities for regenerating specific tissues and replacing specific teeth [2].

The dental pulp has different functions, including protecting the teeth from infections using immunological surveillance, preserving the flexible strength of the teeth to avoid tooth-related fractures, and accelerating dentin formation to avoid external stimuli [3]. Oral health exists right down our priority list despite the worldwide presence of dental caries among a major population of individuals. The problem could be simple, but when the caries is found deep under, dentists prefer to do a pulpectomy [4]. Pulpectomy is the complete removal of the dental pulp without any remnants of the dental pulp stem cells (DPSCs) for regeneration purposes later [5]. But the latest strategy of local

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regeneration therapy of the dentin-pulp complex helps in skipping the pulpectomy process altogether [5]. Stem cells, also known as progenitor/precursor cells, have the unique trait of self-renewal and multi-lineage differentiation. [6]. The ability of stem cells to offer therapeutic possibilities for restoring any structural defects has been the latest buzz among researchers and the dental pulp regenerative capacity of stem cells is evolving well with constant research [6]. Most organs of the human body, including the brain, liver, skin, and blood tissue stem or progenitor cells have restrained differentiation abilities. The dental tissue stem or progenitor cells present in adult tissues help in the repair of the dentin and periodontal ligament [2]. Dental stem cells are holding a pivotal role during recent times as they thrive as the cornerstone for the development of cell transplantation therapies that correct periodontal disorders and damaged dentin. This review article discusses about the application of dental pulp stem cells in Regenerative therapy.

Methodology

The most recognized electronic databases were searched for the data pertaining to the papers that have reported on Regenerative therapy by dental pulp stem cells. PubMed, Google Scholar, Web of Science, Scopus were the keydata bases. Search was carried out for articles published in peer reviewed journals.

Electronic databases searched articles using many Medical Subheadings (MeSH keywords). Regenerative therapy, Dental pulp stem cells, Tooth regeneration, Applications, Regeneration, Endodontic therapy, periodontal regeneration. These key terms were combined in the advanced search using the Boolean operators AND/OR. English language filters were also used. After a thorough search, articles were categorized for their applications.

Applications

Regenerative therapy is the process of replacing/regenerating human cells, organs, and tissues for therapeutic applications [7]. Surprisingly, the concept of regeneration has existed for a long time but wasn't well received until 1932 when the stomatologist G.L. Feldman regenerated dental pulp [6]. But the ground-breaking discovery that altered the course of regenerative therapy didn't happen until the year 2000 when Gronthos et al. isolated and identified an odontogenic progenitor population in the adult dental pulp, and such cells were called dental pulp stem cells (DPSCs) [8]. Dental Stem Cells (DSCs) in humans could be categorized as DPSCs, stem cells from human exfoliated deciduous teeth (SHEDs), stem cells from apical papilla (SCAP), and periodontal ligament stem cells (PDLSCs). DSCs are used therapeutically for different organ systems and numerous diseases, including neurological disorders, diabetes, liver disease, bone tissue engineering, and dentistry. Presently, the focus is on predominantly regenerating the pulp, damaged dentin, repair perforations, periodontal regenerations, and resorbed root, besides using DSCs for quicker healing of the wounds and ulcers, generating salivary proteins and oral microbial colonization [6]. Above all, whole tooth regeneration has been constantly under research.

Regenerative Endodontic Therapy

Any endodontically treated teeth are viable for weakness as a result of dental caries and prosthodontic treatment, thereby increasing the risk of root fracture and even extraction of the tooth [9, 10]. Hence, the purpose of endodontic therapy includes total dentin/pulp complex regeneration that, in turn includes vascularization, pulp immunity, pulp innervation, and tubular dentin formation [11]. Dentin/pulp regeneration is feasible using DPSCs and SHEDs, both of which are safe and have promising benefits. Amongst the dental-derived stem cells, SHEDs are the most accessible ones as they cause no tooth pain but offer humongous regenerative abilities [12]. Regeneration of the pulp-dentin complex is a

huge challenge, and this is where SHED enhances the possibility for better life of the tooth and facilitates better aspects of tooth regeneration [12]. Removing the necrotic pulp tissues was the conventional strategy followed for the treatment of an infected root pulp and replacing them with bioinert cement to block the root canal [1]. While this procedure sounds simple and effective, the only downside is the inability to restore the lost dental pulp tissue and the tooth's vitality [1].

A study by Miura et al. Showed that transplanting SHEDs with hydroxyapatite/tricalcium phosphate (HA/TCP) led to dentin formation in immune-compromised mice, and even this did not happen across all species under research. [13] A couple of other studies showed that SHEDs transplanted with hydrogel, collagen type 1, or PPLA in immune-compromised mice led to the formation of pulp-like tissues, including blood vessels and odontoblasts [14, 15]. Total pulp regeneration with neurogenesis and vasculogenesis was achieved in an adult canine using pulpectomy and pulp transplantation [17]. Various results proved one fact—complete regeneration of the dentin-pulp complex in vivo wasn't successful [16].

The differentiation of SHEDs into odontoblasts in human root canals was discovered by Rosa et al., and such odontoblasts regenerated dentin [18]. Currently, local regenerative pulp treatments using vital pulp can regenerate only the dentin-pulp complex without sufficient blood supply. Making use of modern tissue engineering that recaps the amputated pulp in combination with scaffolds, stem cells, and growth factors enables pulp tissue regeneration alongside the collateral blood supplement dentin-like hard tissue formation [5]. Total pulp regeneration with vasculogenesis and neurogenesis was successful in an adult canine model with pulpectomy and pulp transplantation. Likewise, using mobilized DPSCs to pulpectomized dog teeth showed pulp regeneration without any adverse effects with the treated teeth showing pulp recovery [1]. A study by Rosa et al. showed that transplanting SHED into human root canals produced functional odontoblasts capable of regenerating tubular dentin [14]. Pulp revascularization could become possible in the future using a combination of disinfection and debridement of infected root canal systems alongside the use of stem cells, growth factors, and scaffolds [1]. Various ongoing studies also offer the hope of viability restoration in the necrotic young permanent tooth with the production of the new dental pulp.

A study by Khorsand et al. that transplanted DPSCs into a canine periodontitis model showed successful cementum and PDL tissue regeneration [11]. DPSCs elevated the human salivary gland (HSG) differentiation into functional gland tissues when mixing and transplanting them into immunocompromised mice [11].

Another study by Dissanayaka et al, showed that spheroids of DPSCs prepared using umbilical vein stem cells and implanting them with a tooth slice in immunodeficient mice resulted in pulp-like tissue regeneration [11]. Various studies show that DPSCs are better for dentin/pulp regeneration complex compared to SHED as better clarity is needed on SHED's features to incorporate them in the clinical setting [11].

Dentin formation alongside pulp-like tissue occurrence was evident in immune-deficient mice when DPSCs were used in combination with HA/TCP [19-24]. DPSCs, in combination with fibrin/TCP, resulted in the formation of dentin-like tissue when transplanted into the renal capsule of mice [25, 26]. We also have research clearly showing the importance of growth factor (GF) concentrations in the dentin matrix as these GFs come in direct contact with the pulp and hence, in turn, affect DPSC proliferation during the initial stages of pulp repair [27]. Wnt3A, bFGF, SDF-1, and G-CSF are some of the prominent GFs that showcase the proliferative effect on DPSCs [11].

Periodontal Tissue Regeneration

WHO statistics show that at least 10-15% of the world population is affected by advanced periodontitis [28]. Clinicians have achieved successful results using various surgical procedures, and the discovery of stem cells could be an excellent tool for periodontal regeneration in the coming years. But the very high prevalence of periodontitis and PDL's role in maintaining tooth health has turned our attention toward the engineering of the PDL tissue [1]. Periodontal ligament (PDL) is the highly specialized connective tissue that encircles the root of teeth contributing toward ingraining the teeth in the jaw, feeding, repairing, and harbouring progenitor cell groups called as PDLSCs and maintaining tooth homeostasis. [29]. One of the latest reports founds that PDLSC-implanted mice were able to generate cementum-like structures that imbibe the characteristics of natural PDL [29,30]. Such results show clear evidence for the possibility of the formation of periodontal structures in which the cementum and PDL are included as well. Some factors affecting the regenerative capacity of the PDLSCs are the scaffolds that help in transplantation. The first transplantation of the human PDLSCs on a scaffold from HA/TCP was done on animal models resulting in the regeneration of cementum and PDL-like structures [31]. Such positive results were a motivating factor for other researchers to use PDLSCs in many other animals, including mice, rats, dogs, and many more, combining with different biomaterials as scaffolds (such as gelatin sponge, HA disks, β-tricalcium phosphate/type I collagen, and nerve fibers) to regenerate the periodontium tissues successfully [32-34].

Such positive outputs suggested that it's possible to generate cementum-like tissues and dentin/pulp-like structures using dental bud cells (DBCs), autologous or allogenic PDLSCs grafts, etc. When the appropriate scaffolds are used, the initial cell concentration is optimized [32, 35] Dental tissue stem cells are currently being used in cell transplantation therapies for correcting dentin and periodontal disorders. We have a study showing that the efflux of fluorescent dye Hoechst 33342 fetched from the human dental pulp cells and periodontal stem cells fetched from human extracted teeth led to partial regeneration of dentin and periodontal tissues in adult teeth. [2] Recreating a new PDL after the in-vivo implantation of dental follicle stem cells has also been successful. [1] Continuous efforts are still taken to come up with the perfect delivery system that could help in achieving a good cell-based therapeutic tool for regenerating periodontal tissue [36].

Whole Tooth Regeneration

Tooth loss not only affects an individual physically but also compromises the quality of life of the patient ruining their mental health as well. While this is a primary contributing factor, the regeneration of various tooth elements motivates scientists to delve into the aspect of entire tooth regeneration [5]. Any tooth is a combination of both hard and soft tissues, with the enamel, cementum, and dentin comprising the vascularized hard tissues surrounding the dental pulp. Building a tooth (in vivo or in vitro) needs the association of the odontogenic mesenchymal cells and epithelial cells [37]. Any bioengineered tooth should include root generation and PDL containing the nerve and blood supplies. Any whole tooth regeneration using tissue engineering follows one of the two methods, namely the scaffold method or the recombined tooth germs/cell aggregates method [1]. The scaffold method makes use of stem or precursor cells having a proper spatial orientation with the help of collagen sponge scaffolds or polymer membranes that are biodegradable [38, 39]. However, various research has reported a higher success rate when using collagen sponge scaffolds, in comparison to a biodegradable polymer [39]. Also, the sequential arrangement of the epithelial and mesenchymal cells within the scaffold enhances

the tissue arrangement of the bioengineered teeth [40].

In the recombined tooth germs method, tooth formation relies upon using the DMSCs and the dental epithelial stem cells (DESCs) that are then transplanted into the alveolar bone to enable further eruption and growth from the gingiva [5]. Combining the extracted dental epithelial tissue and the mesenchymal cells of the cell pellet isolated from the E13.5 mice molar tooth germ, the artificial tooth germ developed and, as a result produced the desirable tooth structure by transplantation into the subrena capsule [41]. Tooth generation resulted along with periodontal-like tissue formation, owing to the regeneration of the tooth germ between the dissociated epithelial and mesenchymal cells of the E14.5 molar germ [42, 43]. It's also been proved that artificial tooth root formation is possible by combining the dental pulp stem cells and the periodontal ligament stem cells placed on separate scaffolds [44]. The latest development is a novel bioengineered method whose scope could be extended to growing various tooth types, such as molars and incisors [2].

The topmost hurdle in establishing successful dental regenerative therapies is nurturing the growth of bioengineered tooth germ in an adult environment [2]. However, recent research showed that a bioengineered tooth germ primordium isolated from a bioengineered tooth germ has the potential of growing into a tooth having the dentin, enamel, root, periodontal ligament, dental pulp, alveolar bone, and blood vessels in the tooth cavity after extracting the mandibular incisor [45].

Limitations

On one hand, stem cell-based regenerative therapy seems to hold the key to the repair of defective functions and tissues with the use of appropriate strategy, but being a relatively new area of research, dental pulp stem cells in regenerative therapy face various hurdles and risks. For instance, some of the primary parameters, including stem cell density and availability, besides making use of the right strategies need to be chosen carefully [1]. Besides these, a very important concern among dentists is dealing with immunity-related issues and controlling infections during cell transplantations, root canal treatments, and intracanal medicaments [4]. Ensuring complete dentin formation that covers the regenerated pulp is another challenging issue to deal with to prevent microleakage [4]. Immune rejections during cell transplantation must be dealt with tactically with maximum biosecurity. Cell-based medicinal products don't guarantee sterilization, removal/inactivation of the virus, and purification and if proper care isn't taken, any transfer of viral, bacterial, or fungal pathogens could prove to be life-threatening [46,47].

Conclusions

Exponential research on stem cell therapies for human use is happening continuously, but the progress of such therapeutic applications is proceeding slowly. Research on dental regenerative medicine gives us hope for organ replacement besides stem cell transplantation, but we are yet to reach a stage wherein the patient's cells could be used to stay out of any rejections. Dental-origin stem cells have eminent potential for multi-purpose applications but come with certain limitations currently, as a major portion of the research is still confined to animal models. We need vigorous and extensive clinical testing and research to enable the same in humans. Though we have reached a stage where the production of a teeth-like structure is possible, this cannot replace the actual tooth as more research is needed to grow the nerve and blood supply of teeth, for enabling complete tooth functionality. Constant evolution in the tissue engineering methodology coupled with a better understanding of DSC biology could provide the perfect platform for better use of DSC in regeneration therapy. The next decade could be a crucial junction where huge leaps in stem cell-based regenerative therapies could

become a reality with successful tissue engineering therapies, this could be a biological alternative to synthetic materials that are in use currently. But dental stem cells have their share of challenges for which the research must happen effectively adhering to social responsibilities at all levels.

Conflict of Interest

There is no conflict of interest.

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Regenerative Therapy in Dentistry: A Review

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Abstract

Despite millions of people suffering from dental caries and periodontitis to date, we don't have effective treatments that guarantee complete restoration of the impacted tissues. The current procedures mostly help in delaying the disease progress, and hence, bringing alternative approaches for whole tooth replacement has become indispensable. Considering the scenario, regenerative medicine seems to be the novel approach, given its innovative therapeutic techniques that aid in the repair and replacement of damaged, aged, diseased, or congenitally defective tissues and organs. While we are yet to overcome various challenges, including effective ways to control the size, color, and shape of the tooth and come up with the perfect implantation sites for the jaw to enable in vitro tooth development, the ongoing research and their favorable results reveal that whole-tooth regeneration and bioengineered functional tooth are not a distant dream.

Keywords*: Regeneration, Regenerative therapy, Scaffolds, Tissue engineering.*

Introduction

Globally, millions of people have been suffering from dental caries and periodontitis since time unknown but unfortunately, we don't have effective treatments or cure for complete restoration of the impacted tissues [1]. The general treatment modalities followed include those that delay the progress of the disease or aim for restoration [1]. One of the commonest and most popular indications of early ageing is tooth loss. Edentulism (lack of teeth) not only minimizes oral and social functionality but also affects the quality of life of the individual being a dominant health concern among the general public [2]. Edentulism has been corrected using various methods, the most important of which is complete denture therapy. But there are a couple of disadvantages associated with the therapy including burning mouth syndrome, denture-induced stomatitis, ulcers, change in identifying taste, and soft tissue hyperplasia [3]. Some of the treatment procedures pursed for defective tooth include implantation, use of prosthetics, and transplantation of the tooth but sadly, such processes bring with them loads of downsides including unnecessary load imposition on the neighbouring tissues and improper alignment of the teeth due to growth of the jaw bones [4]. All these make it indispensable to bring in alternative approaches for tooth replacement. Considering the scenario, the pros and cons, and practical application, regenerative medicine seems to be the novel approach for regeneration, given its innovative therapeutic techniques that aid in the repair and replacement of the damaged, aged, diseased, or congenitally defective tissues and organs [5, 6]. Regenerative therapy or regenerative dentistry is making use of our understanding of the cell and molecular biology to devise effective dental

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solutions that focus primarily on repair, restoration, rejuvenation, and regeneration of dental tissues [7]. In simple words, regenerative therapy is nothing but the utilization of biomaterials, cells, and molecules to rectify those parts of the human body which don't perform their designated functions due to some injury or disease [8].

Methodology

The most recognized electronic databases were searched for the data pertaining to the papers that have reported on Regenerative therapy. PubMed, Google Scholar, Web of Science, Scopus were the keydata bases. Search was carried out for articles published in peer reviewed journals.

Electronic databases searched articles using many Medical Subheadings (MeSH keywords). Regenerative therapy, Tissue engineering, Applications, Regeneration, Scaffolds. These key terms were combined in the advanced search using the Boolean operators AND/OR. English language filters were also used. After a thorough search, articles were categorized for their applications.

Applications

When there are umpteen traditional drugs capable of relieving pain and offering treatment, what makes regenerative therapy an exclusive treatment strategy compared to such drugs? The reason is crystal-clear: while drug-based treatments focus predominantly on treating the symptoms of the problem, regenerative therapies delve into the root cause of the problem such as correcting a faulty gene or assist in replacing flawed/lost organs [8]. The medical field by itself relies on a precise perception of the tissue's biology or the disease's processes. With the advent of cutting-edge technologies such as single cell analysis, genomics, gene editing, and stem cells, medicine is all set to enter a new era [7]. Contrarily, there are very few dental treatment procedures that combine tissue regeneration for therapy. In fact, we don't see the application of regenerative treatment procedures in most areas of mainstream medicine. The earliest form of cell therapy was blood transfusion which is now very common. It then progressed to bone marrow transplantation making it super beneficial for cancer patients to make healthy blood cells. Even a person's own cells are used in case of burn-related injuries to grow skin cells in a short period of time [8].

Stem cells are unspecialized cells that can self-renew and differentiate into various types of specialized cells [9]. It's no secret that the teeth and its surrounding tissues are overloaded with stem cells—the growing roots, tooth pulp, alveolar bone, and the periodontal ligament are some of the popular sources of general stem cells [7]. Such dental stem cells present in different dental tissues including the human exfoliated deciduous teeth, periodontal ligament stem cells, dental pulp stem cells, dental follicle precursor cells, and periodontal ligament stem cells are an asset in various ways [10]:

1. Easily accessible and least invasive.
2. A positive synergy with the scaffolds.
3. Multi-differentiation ability.

A sophisticated study centred around the design and use of biological-based material as scaffolds for in-vivo regeneration of periodontal tissues [11, 12]. The various sources of these stem cells include the bone marrow (BM), periodontal ligament (PDL), and more combining them with different bone grafting techniques such as xenografts, autografts, allographs, and alloplastic materials [12]. The applications of stem cells-based techniques have covered a fairly extensive area and are now at a stage where the missing teeth can be replaced with bioengineered teeth, a huge advancement in the field of dentistry [13].

Tooth Tissue Engineering

Before the advent of tooth engineering, partial tooth tissue restoration was possible using calcium hydroxide in pulp-capping procedures [14] But now, tissue engineering

makes use of progenitor cell populations (stem cells) that are grown in biocompatible materials under suitable environmental conditions—these become fully functional tissue replacements.

Periodontal Tissue Regeneration

The ultimate goal of periodontal therapy is tissue regeneration, and this covers the complete formation of the periodontium including the periodontal ligament (PDL), cementum, gingiva, and the alveolar bone [15]. During the early decades, the procedures followed to regenerate periodontal tissues weren't much successful as they resulted in tooth root resorption and ankylosis [16]. But now, tissue regeneration is the default go-to solution for periodontal tissue regeneration, but this has its limited success percentage. Bone morphogenetic proteins, platelet-derived growth factor, recombinant amelogenin protein, and emdogain are the most commonly used growth factors for regeneration of the PDL. It's even been possible to construct a root-periodontal tissue complex by making use of pelleted hydroxyapatite or tricalcium phosphate scaffold that contain DSCs of the apical papilla (SCAP), that are coated with PDL stem cells (PDLSC)-seeded gel foam and implanted and nurtured in a minipig tooth socket [17].

Regeneration of the Entire Tooth

With more than two decades of intensive research, there is in-depth understanding regarding the molecular processes that determine tooth development. Such research and knowledge are indispensable for the formation of a 100% biological replacement tooth.

There are two possible ways in which it's possible to regenerate the entire tooth—the first is making use of the in vitro growth of immature tooth structures from dental progenitor cells and doing their in vivo implantation [15].

It's possible to produce tooth crowns using fully intact or partially dissected tooth germs under suitable environments such as in vivo grafting on chick chorioaltantoic membrane, sub-cutaneous transplants, or ocular or subrenal grafts, or in vitro organ culture [18-20]. Both, nutrients, and oxygen are supplied by every implant site to allow the tooth germ differentiation into a mature tooth. It's possible to enable small tooth primordia in various ways before they are fitted into the required jaw position. By far, in vitro teeth growth has been successful with the use of organotypic culture [15].

Even under the absence of any positional memory, it's possible to bring about dental epithelial cell histogenesis with the help of cap stage dental mesenchyme. Such nurturing subsequently leads to the formation of functional odontoblasts and ameloblasts as well as cusp and pulp formation. Tooth roots and PDL tissues are also possible with prolonged culture time [21]. Making use of dental cell-seeded tooth scaffold constructs, dental mesenchymal cell-seeded] polyglycolic acid mesh, and dental cell-seeded collagen sponge gels, we've reached a stage wherein the tooth size and shape can be controlled in a better way bringing about better organized tooth structure. Another study showed the possibility of forming the cementum and PDL, the complex dentin-pulp complex, with the help of gelatin-chondroitin-hyaluronan-tri-copolymer [22]. Despite all these, we are still at a juncture where in vitro whole-tooth regeneration needs more improvements and progress.

Using Scaffolds in Regenerative Therapy

Among the many techniques used to regenerate a tooth, synthetic scaffold-based tooth regeneration using pre-designed scaffolds thrives as one of the most successful ways [23]. Scaffolds are nothing but structures that provide us with a 3-dimensional substrate helping with proliferation and cell adhesion, similar to the extracellular matrix (ECM) [24].

Scaffolds can be natural or synthetic—synthetic scaffolds are monomers that

polymerize for providing the scaffold's architecture. Some commonly used polymers for scaffold construction include polylactic glycolic acid (PLGA), poly-lactic acid (PLLA), and hydrogels [24-26]. Fibrin and collagen scaffolds are some of the best natural polymers well-known for providing cell compatibility. The tissue type formed depends on the stiffness of the scaffold, the space between the formed pores, and the topography [27]. Scaffold sterilization, exact fabrication of an economic but exact model, and constructing the perfect scaffold with the correct scaffolding material to replicate the dental structure morphology that mimics the natural ECM is a daunting task [23]. Blood plasmatic concentrates possess high concentrations of growth factors thereby overloading them with bioactive molecules, hence making the concentrates one of the best natural scaffold choices. In recent times, blood plasma concentrates have been predominantly used in the field of dentistry for various purposes including root canal revascularization, guided bone regeneration, root coatings, regeneration of intraosseous periodontal defects, and adjuvants in osseointegration of implants [28].

Periodontal Tissue Regeneration

Any tooth support segments lost as a consequence of periodontitis or gingival trauma can be restored using periodontal regenerative therapy whose main focus is formation of a new cementum at the tooth's root [28]. Until now, periodontal regenerative therapies have been mostly done in vitro and experimented on animal models. But there have been some clinical trials conducted one of which is a randomized control trial done by Pradeep et al. Results showed that the use of blood concentrates showed better treatment results of regenerated bone defects. Also, the use of platelet-rich fibre (PRF) in combination with metformin (1%) exhibited better bone repair compared to traditional techniques and PRF [29, 30].

Tooth Regeneration with Cell Homing

An alternative to cell transplantation in tooth regeneration is the use of cell homing as there are multiple advantages attached with this process—excluding the need for cell isolation, ex-vivo cell manipulation, exclusion of the need for regulatory approvals, and decreased commercial cost comparatively [13]. One of the first studies done by Kim et al., reported the formation of tooth-like tissues using cell homing. With in-depth research, the future seems bright for using cell homing in clinical practice [31, 32].

Limitations

One of the greatest challenges for regenerative therapy is to move past the non-biological methodologies and rely upon tissue-based therapies through better research, clinical translation, and spread of knowledge to spotlight the novel side of dental treatment [7]. Also, inability of adult stem cells to enable cell differentiation post-transplantation is one of the huge limitations linked with tissue-based engineering [7]. Reproducing the whole human teeth with the functional enamel intact is an arduous task firstly because enamel formation leads to apoptosis of the dental epithelial cells wiping away their presence in the erupted tooth. Secondly, expanding epithelial cells is a strenuous process compared to mesenchymal cells. Hence, alternative sources of the dental epithelial cell are the dire need of the hour. Another concern is also whether the jaw will be supportive of the bioengineered tooth germs grown in it. The dental follicle is indispensable for the eruption of the tooth and absence of the follicle guarantees zero tooth eruption. So, even when a silicon tooth is fit in the place of a developing tooth, the process is successful only when the follicle is retained. Hence, when designing the tooth organs, the inclusion of the dental follicle remains mandatory [15].

Till date, there have only been a few successful reports of bioengineered root tooth formation with functional PDL tissues as

whole-root regeneration is a complete success only when the tooth crown and the root structures are fully functional. [33] Another main concern is the immune response to such bioengineered human tooth which remains an unchartered territory until now. In short, there are various clinical, biological, and technical challenges associated with tooth regeneration. While dentists are at a stage where they can manage periodontal diseases using stem cells and scaffolds, coming up with whole-tooth regeneration using regenerative therapy is still challenging and needs further research [9].

Conclusions

Complete loss of a tooth causes both mental and physical agony deteriorating the quality of life of the patient. Dentistry has reached the stage of total tooth regeneration only after achieving success in regenerating various tooth elements [13]. Tooth formation happens through different hard and soft tissues. The hard tissues include the enamel, cementum, and dentin encompassing the dental pulp as the single source of vascularized tissue in the teeth [34, 35]. For dental use, the concept of tissue engineering and stem cell therapy are classic ways for regeneration of the bones and soft tissues whose research and studies show hope for future application. Using tissue engineering, it would be possible for repairing and re-growing teeth even after extreme tooth damage and tooth loss [10]. Bone and periodontal regeneration have attained clinical success and root canal re-vascularization techniques and different regenerative procedures make use of tissue engineering clearly indicating monumental leaps in the field of dentistry [28].

While we are yet to overcome various challenges including effective ways to control the size, color, and shape of the tooth, ensure fully functional eruption of the tooth, and come up with the perfect implantation sites for the jaw to enable in vitro tooth development, with the current progress and achievements, whole-tooth regeneration and bioengineered functional tooth are not a distant dream [28]. But before all this, to include regenerative therapy as a part of mainstream medical care, various issues including immunity, ethics, clinical constraints, technologies, cost, risks, and benefits possible for the patient and the society as a whole must be considered and researched through long-term follow-up clinical trials.

Conflict of Interest

There is no conflict of interest.

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