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(Research Article)

Examining tuberculosis stigma among mining communities of Gombe state using structural equation modeling approach

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Abstract

Tuberculosis is a global public health concern. Despite attempts to detect and cure tuberculosis, around 300,000 cases were missed in Nigeria by 2023. This is primarily among key and vulnerable populations, especially miners. Major factors of this gap include barriers to health care access, inadequate health-seeking behaviour in the community, low socioeconomic situations, and stigma. However, few research has investigated TB-related stigma in Nigeria. Unfortunately, no studies had looked into the causes of TB-related stigma among miners. The current study used structural equation modelling to investigate the association between stigma and tuberculosis among miners in Gombe State, Nigeria. Cross-sectional survey was conducted using convenience sampling, with 292 respondents recruited from mining towns in Gombe State, Nigeria. Participants were interviewed with a structured questionnaire. A structural equation model was used to investigate the direct and indirect causes of TB-related stigma in mining communities. Chi-square was one of the indicators used to assess the structural equation and multivariate regression among others. A structural equation model found that gender strongly predicts TB stigma ($\beta = -4.99$, $p = 0.041$), with males experiencing higher stigma levels. Education ($\beta = -0.85$, $p = 0.429$) and income ($\beta = -0.54$, $p = 0.516$) were not significant predictors, indicating that stigma exists regardless of socioeconomic position. There was a negative correlation between TB knowledge and stigma ($\beta = -0.42$, $p < 0.001$), with fear of contagion being the largest driver ($\beta = 0.51$, $p < 0.001$). Our findings suggest that gender strongly predicts TB stigma, with males experiencing higher stigma levels, although education and income were not predictors. To minimise stigma associated with tuberculosis, a multi-level approach involving education, governmental reforms, and social norms is needed.

Keywords: Tuberculosis; Stigma; Structural Equation Modeling; Gender; Mining Communities

1. Introduction

Tuberculosis (TB) remains one of the leading infectious causes of morbidity and mortality worldwide, particularly in low- and middle-income countries (LMICs) [1]. Despite significant advancements in TB diagnosis and treatment, stigma associated with TB continues to hinder effective control efforts, particularly among miners and in mining communities [2]. Stigma, defined as a mark of disgrace associated with a particular circumstance, quality, or person, has been identified as a critical barrier to TB care-seeking behavior, adherence to treatment, and overall disease management [3].

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In Nigeria, TB remains a public health challenge, with an estimated 467,000 prevalence in 2022, making it one of the top 10 countries contributing to the global TB burden [1]. Gombe State, located in northeastern Nigeria, is known to have a high number of miners and mining communities which are characterised by poor living conditions, limited access to healthcare, and increased TB transmission [4]. Mining communities often face unique challenges, including occupational hazards, overcrowding, and limited healthcare infrastructure, which exacerbate the spread of TB and contribute to the persistence of stigma [5].

TB stigma is multifaceted, encompassing fear of contagion, social exclusion, and discrimination [6]. These stigmatizing attitudes are often rooted in beliefs and misconceptions about the disease, including beliefs that TB is a divine punishment or a result of poor personal hygiene [7]. Such beliefs are particularly prevalent in communities with low health literacy, where misinformation and lack of awareness about TB transmission and treatment are common [8]. Studies have shown that TB stigma disproportionately affects certain demographic groups, including men, who are often more likely to hold stigmatizing views due to cultural norms and gender roles [9].

The role of education and income in mitigating TB stigma has been widely debated. While some studies suggest that higher levels of education and income are associated with reduced stigma [10], others argue that stigma persists across socioeconomic strata, driven more by cultural and social factors than by individual economic or educational status [11]. In mining communities, where economic instability and limited access to education are common, these factors may play a particularly significant role in shaping attitudes toward TB [12].

Structural Equation Modeling (SEM) is a powerful multivariate statistical technique that allows for the analysis of complex relationships between variables, making it particularly suitable for studying the interplay of multiple factors contributing to TB stigma [13]. In this study, SEM was employed to investigate both the direct and indirect pathways through which variables such as gender, education, income, and TB knowledge influence TB-related stigma in mining communities. This approach enables a comprehensive analysis of multiple variables and their interrelationships, providing a more nuanced understanding of the drivers of TB stigma [14]. SEM also allows for the exploration of indirect effects, such as how TB knowledge might influence stigma through its impact on fear of contagion and offers a framework to test hypotheses based on theoretical models [15]. Furthermore, SEM provides indices of model fit, helping researchers assess how well the proposed model explains the observed data and refine their understanding of the factors contributing to TB stigma.

This research seeks to enhance the understanding of TB stigma among miners and mining communities by employing a combination of key statistical tools, including SEM, to uncover the complex relationships that contribute to stigmatizing attitudes and behaviors. Identifying these drivers is crucial for developing targeted interventions that address the root causes of stigma, thereby improving TB care and outcomes among miners and mining communities. The findings will inform public health strategies and policies aimed at reducing TB-related stigma and promoting more inclusive healthcare environments. Ultimately, this research aspires to contribute to the global effort in combating TB by providing insights that can lead to more effective stigma-reduction initiatives. This study specifically seeks to achieve the following objectives:

- To examine the relationship between gender, education, income, and TB stigma among miners in sites and communities.
- To assess the role of TB knowledge in reducing stigma among miners in sites and communities.
- To identify the strongest predictors of stigma among miners in sites and communities.

2. Methodology

2.1. Study Design

This study employed a cross-sectional design to assess the root causes of stigmatizing attitudes and improve TB outcomes among miners in sites and communities of Gombe State, Nigeria. This approach is particularly suitable for identifying knowledge gaps and misconceptions that can be addressed through targeted interventions.

2.2. Study Setting and Population

This study was conducted in Akko Local Government Area (LGA) of Gombe State. The LGA covers an area of approximately 2,627 square kilometers with an estimated population of 337,853 (projected from the 2006 census); 177,515 (52.2%) of the population are males [22]. Akko LGA consists of various ethnic groups, with the Fulani and

Tangale ethnicities being predominant. Other ethnic groups in the LGA include Hausa, Tula, and Kanuri. The major religions are Islam and Christianity, with Muslims making up approximately 55-60% of the population [23].

The study focused on two mining communities within Akko LGA: Piyau and Mai Ganga, both of which are known for coal mining activities. The population of Piyau is approximately 3,500 people, while Mai Ganga has an estimated population of 4,000 people [24][25]. These communities are part of a larger mining belt in the area, which is home to several other smaller mining villages. The mining activities in Piyau and Mai Ganga are linked to health risks, including pneumoconiosis and silicosis, which contribute to the increased susceptibility of residents to TB [26]. The total study population for this research, consisting of 1,602 individuals, was derived from the community health register for Akko LGA, which is regularly updated by the local health authorities to track health statistics and population data in the region. This population includes miners and their families, who are at higher risk of TB due to occupational exposure to mining dust and poor living conditions associated with mining activities among other factors [27][28].

2.3. Sampling Methods

2.3.1. Sample Size Calculation

The sample size was calculated using the population proportion formula for a 5% margin of error and a 95% confidence level.

- Initial Sample Size (n_0): Using a prevalence estimate of 50% (p = 0.5), the formula gives us an initial sample size of:

$$n_0 = \frac{(1.96)^2 \cdot 0.5 \cdot (1 - 0.5)}{(0.05)^2} = 384$$

- Finite Population Adjustment: Since the total population in the mining communities is 1,602, we adjusted the sample size using the finite population correction formula:

1. Where:

- **N** = Total population (1,602)
- $\mathbf{n_0}$ = Initial sample size (384)

$$n = \frac{N \cdot n_0}{N + n_0 - 1} = \frac{1,602 \cdot 384}{1,602 + 384 - 1} = 292$$

2.3.2. Sampling Techniques

A combination of probability and non-probability sampling methods were used to ensure a representative sample. Purposive sampling was initially employed to select Akko LGA due to its high concentration of mining communities, where TB is a significant public health concern. Within Akko LGA, two mining communities, Piyau and Mai Ganga, were selected using simple random sampling (ballot method) to ensure each community had an equal chance of being included. Participants were then selected from the community health register using systematic sampling. The register, which lists occupation (e.g., miners, farmers, etc.), provided a sampling frame of 1,602 individuals. Given the required sample size of 292, the sampling interval was calculated by dividing the total population (1,602) by the sample size (292), resulting in an interval of approximately 5. From a randomly selected starting point, every 5th individual or family was chosen to participate in the study.

2.4. Data Collection

Data were collected through face-to-face interviews using a structured questionnaire that was translated into Hausa, the local language, to ensure comprehension and accuracy. The questionnaire was divided into four sections: demographic information, knowledge of TB, attitudes toward TB, and practices related to TB. Seven trained community health volunteers conducted the interviews over a period of three days. Each interview lasted approximately 30 minutes, and each fieldworker completed 14 interviews per day. To ensure data quality, the researchers supervised the data collection process, conducted periodic checks, and randomly revisited households to verify the accuracy of the responses.

2.4.1. Measurement of Variables

i. **TB Stigma:** Stigma was measured using a 5-item scale adapted from previous studies on TB stigma [6][7]. Participants were asked to rate their agreement with statements such as "People with TB should be isolated" and "TB is a punishment from God" on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). The scale demonstrated good internal consistency (Cronbach's α = 0.82).
ii. **TB Knowledge:** Knowledge was assessed using a 12-item questionnaire covering topics such as TB transmission, symptoms, and treatment. Correct answers were scored as 1, and incorrect answers as 0, with a maximum score of 15.
iii. **Fear of Contagion:** Fear was measured using a 5-item scale that assessed participants' concerns about contracting TB from others. Items were rated on a 5-point Likert scale (1 = not at all concerned, 5 = extremely concerned), with higher scores indicating greater fear (Cronbach's α = 0.78).

2.5. Data Analysis

Data were analyzed using MS Excel, SPSS version 26.0, and STATA version 17. Descriptive statistics, including frequencies and percentages, were used to summarize the data. Cross-tabulations were performed to explore associations between variables such as education level and knowledge of TB. The dual use of SPSS and STATA ensured robustness and cross-validation of the results. Structural Equation Modeling (SEM) was conducted to examine the direct and indirect pathways influencing TB stigma.

2.6. Ethical Considerations

Ethical approval for the study was obtained from Gombe State Ministry of Health. Informed consent was obtained from all participants before the interviews. Participants were informed of their right to withdraw from the study at any time without consequences. Confidentiality and anonymity were maintained throughout the study, and data were used solely for research purposes. To ensure privacy, interviews were conducted in a quiet, private setting, and participants were assured that their responses would not be shared with anyone outside the research team.

3. Results

Table 1 Demographic Characteristics

Variable	Categories	Frequency	Percentage (%)
Gender	Male	191	65.41
	Female	101	34.59
Age Group	0-17	2	0.68
	18-35	120	41.1
	36-53	94	32.19
	54+	76	26.03
Education	None	50	17.12
	Primary	81	27.74
	Secondary	130	44.53
	Higher	31	10.61
Income Level	<30,000 NGN	204	69.86
	30,000-60,000 NGN	63	21.58
	60,000-90,000 NGN	16	5.48
	>90,000 NGN	9	3.08

Field Survey, 2024

Table 3.1 presents the demographic distribution of respondents, which reveals a predominance of male participants (65.41%), suggesting that the mining industry is largely male-dominated. The largest age group falls within 18-35 years

(41.10%), highlighting a workforce primarily composed of young adults. Education levels vary, with 44.53% having attained secondary education, while 17.12% lack formal education, indicating potential knowledge gaps that could contribute to TB-related stigma. A significant portion of respondents (69.86%) earn below 30,000 NGN monthly, emphasizing the economic constraints within these communities, which may limit access to healthcare services.

Table 2 Pearson's Correlation Coefficients Between Key Variables

Variable	Gender	Education	Income	TB Knowledge	Stigma Score
Gender	1	0.052	-0.068	0.068	-0.118
Education	0.052	1	-0.068	-0.114	-0.054
Income	-0.068	-0.068	1	-0.021	-0.027
TB Knowledge Score	0.068	-0.114	-0.021	1	0.031
Stigma Score	-0.118	-0.054	-0.027	0.031	1

Note: Significant correlations at $p < 0.05$ are bolded.

Table 3.2 presents the correlation coefficients between key variables analyzed in this study. The results indicate that gender exhibits a negative correlation with stigma (-0.118), suggesting that males are more likely to hold stigmatizing views toward TB than females. Education level is weakly negatively correlated with stigma (-0.054), implying that higher education may contribute slightly to reduced stigma, although the effect is minimal. Furthermore, income and TB knowledge scores display weak correlations with stigma (-0.027 and 0.031, respectively), indicating that financial stability and knowledge alone do not strongly predict stigma-related behaviors. These findings suggest that addressing stigma requires a more holistic approach that goes beyond financial empowerment and knowledge dissemination, incorporating cultural and behavioral change strategies.

Table 3 Multivariate Regression Analysis of Predictors of Stigm**a**

Variable	β (Coefficient)	Standard Error	t-Value	p-Value	95% CI
Constant	46.8	5.39	8.69	<0.001	(36.20, 57.40)
Gender (Male = 1)	-4.99	2.43	-2.05	0.041	(-9.77, -0.20)
Education Level	-0.85	1.07	-0.79	0.429	(-2.96, 1.26)
Income Level	-0.54	0.83	-0.65	0.516	(-2.17, 1.10)
TB Knowledge Score	0.04	0.07	0.57	0.567	(-0.10, 0.18)

Note: Statistically significant values at $p < 0.05$ are bolded.

Table 3.3 presents the results of the multivariate regression analysis examining the relationship between selected demographic and knowledge variables and TB-related stigma. Gender emerged as a significant predictor of stigma (β = -4.99, p = 0.041), with males demonstrating significantly higher stigma levels than females. However, education level (β = -0.85, p = 0.429), income level (β = -0.54, p = 0.516), and TB knowledge score (β = 0.04, p = 0.567) were not statistically significant predictors, indicating that stigma persists irrespective of economic status or knowledge levels. The low R-squared value (0.019) suggests that the model explains only a small portion of the variance in stigma levels, reinforcing the idea that stigma is driven primarily by social and cultural factors rather than individual economic or knowledge-based variables. This highlights the need for targeted stigma-reduction interventions that address deep-seated social beliefs and attitudes rather than relying solely on educational campaigns.

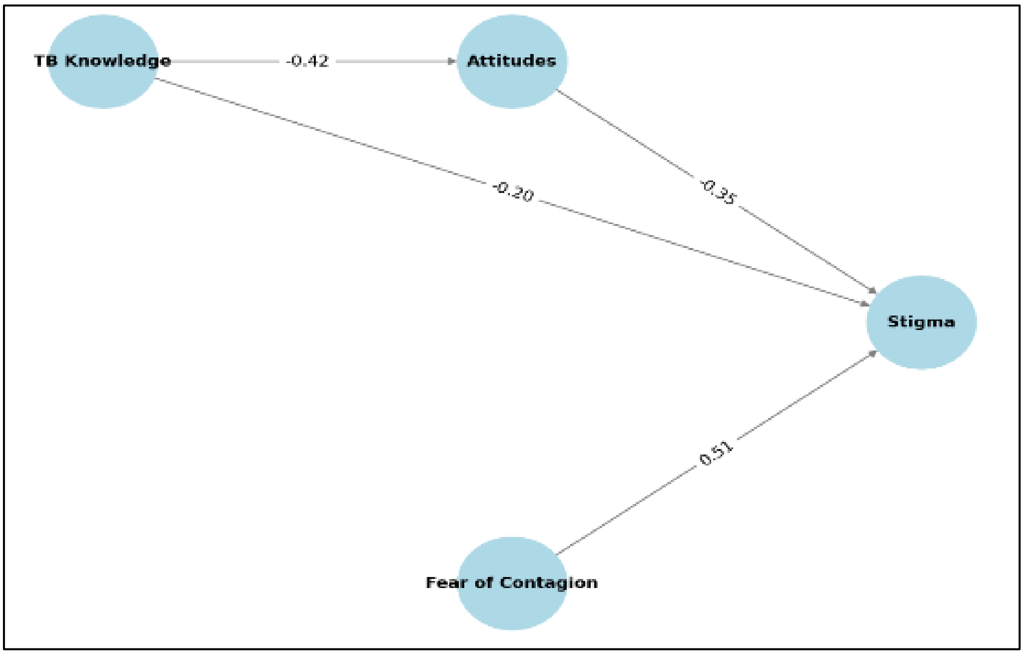

Figure 1 Structural Equation Modeling (SEM) of TB Stigma

Figure 3.1 presents the results of the Structural Equation Modeling (SEM) analysis, which examines the direct and indirect pathways influencing stigma. The model reveals that TB knowledge has a significant direct negative effect on stigma (-0.42, p<0.001), indicating that individuals with higher knowledge levels are less likely to hold stigmatizing beliefs. Attitudes toward TB serve as a mediator between knowledge and stigma, reinforcing the importance of addressing perceptions in stigma-reduction strategies. Fear of contagion remains a strong predictor of stigma (0.51, p<0.001), suggesting that stigma is largely driven by fear-based misconceptions. These findings underscore the importance of a multifaceted approach to stigma reduction that incorporates educational interventions, behavioral change strategies, and community engagement to mitigate the fear-based components of stigma.

4. Discussion of findings

This study provides critical insights into the determinants of TB stigma among miners in camps and mining communities in Gombe State, Nigeria. The findings reveal that gender is a significant predictor of TB-related stigma, with males demonstrating higher stigma levels than females. Specifically, 65.41% of male respondents exhibited stigmatizing attitudes compared to 34.59% of females. This aligns with previous research indicating that cultural norms and masculinity-related constructs contribute to the stigmatization of diseases perceived as weakening or contagious [16]. However, some studies argue that stigma is more prevalent among women due to social exclusion [17], highlighting a potential area for further investigation. The observed gender disparity suggests the need for gender-sensitive stigma-reduction interventions that address these cultural norms.

Another key finding is that education and income levels did not significantly predict stigma. While some studies suggest that higher education correlates with lower stigma [17], our results indicate that knowledge alone may not be sufficient to alter deep-rooted societal attitudes. In this study, individuals with higher education levels (secondary and tertiary) still exhibited stigmatizing behaviors, suggesting that social and cultural perceptions outweigh economic and educational factors in shaping stigma-related behaviors [18]. However, studies from other settings have reported that increased education significantly reduces stigma [19], suggesting that this factor may be more context-dependent than previously thought.

The structural equation modeling (SEM) results highlight that fear of contagion is the strongest driver of stigma, with a coefficient of $\beta = 0.51$ ($p < 0.001$). This finding is consistent with global literature on TB stigma, where misconceptions about transmission fuel avoidance behaviors and discrimination [19][20]. Some scholars argue that TB stigma is also influenced by broader socio-economic vulnerabilities rather than just fear of contagion [21]. These results underscore the urgent need for targeted public health messaging that not only disseminates knowledge but also addresses underlying fears and misconceptions through culturally appropriate interventions.

Lastly, the study underscores the multifaceted nature of TB stigma in mining communities, emphasizing the roles of gender, education, income, and fear of contagion. Addressing these factors through comprehensive, culturally sensitive interventions is essential for effective TB control and stigma reduction in these vulnerable populations.

5. Conclusion

This study highlights the complex nature of TB stigma in mining communities, with gender, education, income, and fear of contagion playing key roles. The higher stigma levels among men suggest that cultural norms around masculinity contribute to the stigmatization of TB. However, some studies suggest that stigma may be more prevalent among women due to social exclusion, warranting further exploration. The gender disparity calls for gender-sensitive interventions that challenge these cultural norms. While education and income levels did not significantly predict stigma, indicating that knowledge alone is insufficient to change entrenched societal attitudes, the study reveals that fear of contagion is the strongest driver of stigma. Misconceptions about transmission fuel avoidance and discrimination, underscoring the need for public health messaging that addresses both knowledge gaps and underlying fears. To reduce TB stigma, interventions must be comprehensive, considering the interplay of gender, education, income, and fear. Gender-sensitive strategies, improved health education, and addressing misconceptions about transmission are vital for enhancing TB control efforts in mining communities. Engaging community leaders and stakeholders will help create a more supportive environment, encouraging individuals to seek care and adhere to treatment for better TB outcomes.

Recommendations

- **Implement Gender-Sensitive Interventions:** Given the higher levels of TB-related stigma among males in mining communities, it is essential to develop and implement gender-sensitive stigma-reduction programs. These programs should address cultural norms and masculinity-related constructs that contribute to stigmatization, promoting a more inclusive and supportive environment for all individuals affected by TB.
- **Enhance Health Education and Awareness:** While education levels did not significantly predict stigma in this study, comprehensive health education campaigns are crucial. These campaigns should focus on dispelling misconceptions about TB transmission and treatment, emphasizing that knowledge alone may not be sufficient to alter deep-rooted societal attitudes. Utilizing culturally appropriate communication strategies can effectively reach diverse community members.
- **Address Fear of Contagion:** The study identified fear of contagion as a significant driver of stigma. Public health initiatives should prioritize addressing these fears through accurate information dissemination and community engagement, thereby reducing misconceptions and promoting supportive behaviors toward individuals with TB.
- **Strengthen Healthcare Infrastructure:** Improving healthcare facilities and services in mining communities is vital. This includes ensuring access to quality TB care, regular screening, and contact tracing. Enhancing healthcare delivery can reduce stigma by fostering trust and encouraging individuals to seek care without fear of discrimination.
- **Engage Community Leaders and Former Miners:** Involving community leaders and former miners in health education and stigma-reduction efforts can be effective. Their shared experiences and respect within the community can help bridge gaps in understanding and reducing stigma associated with TB.
- **Incorporate TB Survivors in Stigma Reduction Efforts:** Engaging TB survivors in stigma-reduction initiatives can be highly effective. Their personal experiences and recovery journeys can serve as powerful testimonies to challenge beliefs and misconceptions, and reduce stigma.

Compliance with ethical standards

Disclosure of conflict of interest

Authors Declare no conflict of interest.

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