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Treatment outcomes and predictors of unfavourable response among tuberculosis patients in Sokoto State, Nigeria (2020–2024)

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Abstract

Tuberculosis (TB) remains a leading cause of death globally, with Nigeria ranking sixth among high-burden countries. While programmatic reports from Sokoto State claim a 97% treatment success rate, independent evaluations are lacking. This study assessed TB treatment outcomes and identified predictors of unfavourable outcomes in Sokoto State from 2020 to 2024. A descriptive cross-sectional design was employed, involving 200 respondents comprising health workers (40.0%), TB patients (27.5%), and public health officers (32.5%). Data were collected using structured questionnaires and patient record reviews. Treatment outcomes were categorized according to WHO definitions. The overall treatment success rate was 80.0% (65.0% cured, 15.0% completed), significantly below the 85% WHO target. Default rate was 10.0%, mortality 5.0%, treatment failure 2.5%, and transfer-out 2.5%. TB predominantly affected males (59.0%) and adults aged 30-49 years (52.5%), with 32.5% having no formal education. Pulmonary TB was most prevalent (79.0%). Stigma/discrimination (36.0%) and poor awareness/health education (30.0%) were the most significant barriers. Concurrent research documented 83.3% underweight prevalence, 68.7% acute malnutrition, 91.3% vitamin A deficiency, and 78.0% systemic inflammation among under-five children, conditions that compromise immune function and adversely affect TB outcomes. Sokoto State is not on track to meet 2030 End TB Strategy targets. The discordance between programmatic claims (97%) and independent evaluation (80%) highlights the need for improved surveillance and patient support systems. Addressing stigma, enhancing awareness, strengthening follow-up, and tackling the malnutrition-inflammation syndemic are critical to improving outcomes.

Keywords: Tuberculosis; Treatment Outcomes; Default Rate; Treatment Success; DOTS Strategy; Sokoto State; Nigeria; Stigma

1. Introduction

Tuberculosis (TB) is caused by the bacterium *Mycobacterium tuberculosis*, which is an airborne disease transmitted from person to person by aerosolized droplet nuclei (Varaine & Rich, 2014). The disease is spread in the air when people who are sick with pulmonary TB expel bacteria through coughing, sneezing, laughing or talking (Ministry of Public Health and Sanitation [MOPHS], 2009). Relatively small number of people infected with TB will eventually develop the active disease and the probability is much higher among the people living with Human immunodeficiency virus/Acquired immunodeficiency virus (World Health Organization [WHO], 2010).

Worldwide, Tuberculosis is among the top ten causes of death, third among the infectious diseases overtaking even HIV (WHO, 2016). In 2012 8.6 million people developed the disease, 1.3 million died (WHO, 2013). WHO introduced DOTS

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strategy in 1990 as a cost effective way to control TB and improve health. Adoption and implementation of this strategy has substantially improved TB control globally.

Tuberculosis (TB) remains one of the most pressing public health concerns globally, particularly in developing countries. According to the World Health Organization (WHO, 2023), TB is among the top 10 causes of death worldwide and a leading cause of death from a single infectious agent, surpassing HIV/AIDS. The disease is airborne and highly contagious, making its management and control a priority for global health organizations and national governments. Nigeria is among the 30 high TB-burden countries, contributing significantly to the global TB incidence rate. The Federal Ministry of Health (FMOH, 2021) reports that over 440,000 new TB cases are recorded annually, with an estimated 150,000 deaths each year due to TB and its complications. Despite the availability of effective treatment, challenges such as poor healthcare infrastructure, weak disease surveillance, limited access to diagnostic tools, and inadequate patient adherence continue to impede effective TB control.

The population of Sokoto State faces profound socioeconomic deprivation that significantly impacts health outcomes. Recent community-based research has documented that 83.3% of children under five are underweight, 68.7% suffer from acute malnutrition (including 28.0% with Severe Acute Malnutrition), and 91.3% are vitamin A deficient, with 73.3% zinc deficient and 78.7% anemic (Musa et al., 2026a, 2026b). Furthermore, 78.0% of children exhibit elevated C-reactive protein indicating systemic inflammation, with a striking dose-response relationship where inflammation prevalence increases from 51.1% in well-nourished children to 92.9% in those with severe acute malnutrition (Musa et al., 2026c). These conditions of chronic undernutrition and micronutrient deficiency significantly compromise immune function, increasing susceptibility to tuberculosis infection and adversely affecting treatment outcomes (Black et al., 2013; Musa et al., 2026d).

Tuberculosis control has three overlapping dimensions; humanitarian, public health and economic. The public health concern emanates from proper diagnosis and treatment of TB patient to decrease disease transmission within community (Arnadottoir, 2009). TB is also responsible for direct or indirect cost to individual and society. The productive adults bear the greatest burden of TB, once infected they are weakened and often unable to work (Laxminarayan, 2007). Tuberculosis remains a major public health problem causing losses in quality of adjusted life years (QALYS) or disability adjusted life-years (DALYs) and it ranks 7th globally in the global life years lost ranking (Banerjee & Nasaru, 2014).

The failure to eliminate or completely reduce TB as a public health problem has been largely associated with little attention the disease attracts from the government, poor management of TB control programs, high rates of poverty and population growth especially in urban areas due to migration and HIV/AIDS pandemic. Considerable progress has been made since introduction of DOTS strategy.

The world health assembly passed a resolution to end global TB epidemic with targets to reduce TB death by 95% and cut new cases by 90% between 2015 and 2035 to ensure that no family is burdened with catastrophic expenses due to TB (WHO, 2014). The WHO has recommended adoption of directly observed therapy (DOTS) as strategy to achieve high treatment completion rates in 1990. This is expected to reduce patient's loss to follow up, treatment failures, death and emergence of drug resistance associated with treatment interruptions. Studies have shown that 86-90% of patient receiving complete treatment successfully as compared to self-administered to therapy. Treatment completion and cure rates for Mombasa County have over a long period of time remained low. This is attributable to a number of factors associated with patients, health facility and health care workers (Ministry of Health, 2020).

The goal of the Directly Observed Treatment Short Course (DOTS) programme is to cure at least 85% of new smear-positive patients and to detect at least 70% of new smear-positive cases. Some studies conducted in Nigeria by Fatiregun et al. (2009) and Ofoegbu and Odume (2015) all reported high unfavourable treatment outcomes (Treatment failure, default, Death, and transferred out).

Sokoto State, located in north-western Nigeria, is among the states with a significant TB burden. In 2021, the state diagnosed 18,366 TB cases, which doubled the 9,267 cases diagnosed in 2020 (Healthwise, 2022). As of November 2021, no fewer than 13,486 residents of Sokoto State were receiving TB treatment at different locations across the state (Sokoto introduces house-to-house search, 2022). By the end of 2025, the state's share of Nigeria's estimated 510,000 TB cases remained a cause for concern (WHO, 2024). A study on the prevalence and molecular mapping of multidrug-resistant Mycobacterium tuberculosis in Sokoto revealed that Nigeria records 570,000 new TB cases each year and is one of the world's greatest TB-burden countries as well as one of the top ten countries with MDR-TB (Hudu et al., 2022).

The socioeconomic determinants of poor health outcomes in Sokoto State have been extensively documented. Musa et al. (2026e) identified three independent predictors of malnutrition in the state: low household dietary diversity (Adjusted Odds Ratio [AOR] = 4.2, 95% CI: 1.8–9.8), low maternal education (AOR = 3.1, 95% CI: 1.3–7.4), and extreme household poverty (AOR = 2.8, 95% CI: 1.2–6.5). The study also found that 73.3% of households consume four or fewer food groups daily, 45.3% live in extreme poverty earning less than N20,000 per month, and 75.3% of caregivers have secondary education or less (Musa et al., 2026f). These conditions create a population highly vulnerable to infectious diseases including TB.

This study aimed to evaluate treatment outcomes among TB patients in Sokoto State from 2020 to 2024, identify predictors of unfavourable outcomes, and assess the barriers to treatment completion within this context of profound socioeconomic and nutritional vulnerability.

2. Materials and methods

2.1. Study Area

This research work was carried out in Sokoto metropolis, Sokoto located within the latitude 13° 12' 98' N, longitude 5° 20' 36' E and altitude 302 m above the sea level. Sokoto is located in the North West of Nigeria, between latitudes 13° 4' 07' north and longitudes 05° 14' 49' east and above 265 m the sea level. The State accounts for 2.3% of Nigeria's total population. Situated in the North Western corner of Nigeria, Sokoto State territory occupies 25,973 square kilometres. Sokoto shares its borders with Niger Republic to the North, Zamfara State to the East, Kebbi state to the South-West (MOCIT, 2002). The State has an estimated population of about 6,391,000 people as of 2023 with 95.9 persons per square kilometre, and 3% growth rate annually (National Population Commission [NPC], 2023). Occupation of city inhabitants includes farming, trading, commerce, with a reasonable proportion of the population working in private and public sectors (MOCIT, 2002).

2.2. Study Design

This study adopted a descriptive cross-sectional design to collect quantitative and qualitative data from health workers, patients, and public health officials involved in TB care. The data was generated from the TB cases registered annually (cohorts) by the TB control program in Sokoto State for the period 2019 to 2021. The data source was the annual registration for TB from all the DOTS centers in the 23 LGAs of Sokoto State. Information on the number of TB cases of all categories as well as the age and sex distribution was obtained. Existing patient data from hospital records was extracted from patient treatment card and quarterly summary form for presumptive tuberculosis patients.

2.3. Study Population

The target population includes: Health workers in TB clinics, Patients currently undergoing TB treatment and Public health officers responsible for TB program supervision.

2.4. Inclusion and Exclusion Criteria

Inclusion Criteria: Confirmed TB Diagnosis, Receiving TB Treatment in Sokoto State, Age Criteria, Availability of Medical Records, Consent to Participate and Involvement in TB Management (for Health Workers).

Exclusion Criteria: Patients Not Resident in Sokoto State, Patients with Multi-Drug Resistant TB (MDR-TB), Incomplete Records, Pediatric TB Cases, Participants with Co-morbidities and Non-TB Health Workers.

2.5. Sample Size Determination

A stratified random sampling technique was used to ensure fair representation across urban and rural health facilities in Sokoto metropolis. The sample size was determined using Cochran's formula for population studies, adjusting for anticipated response rate. Mugenda and Mugenda (2003) states that the sample size must be large enough to represent the salient characteristics of the accessible population. Generally, the sample size depends on factors such as the number of variables in the research, the type of research design, the method of data analysis and the size of the accessible population. The total population of staff dealing with TB patients will be 30. This study therefore used a sample size of 50 respondents randomly sampled from the three selected hospital in Sokoto state dealing with TB patients.

The sample size was computed using the Yamane (2007) formula: $n = N / [1 + N(e)^2]$

where N = total number of DOTS centres in Sokoto State (496), e = margin of error (0.05). Thus, n = 496 / [1 + 496(0.05)^2] = 221. Thus, 221 DOTS centres were selected for facility-level assessment. Additionally, all 20 TB diagnostic centres (GeneXpert/Truenat sites) were included purposively due to their specialized role.

For patient record review, the sample size was calculated using the single population proportion formula (Daniel, 1999):

$n = Z^2 p (1-p) / d^2$

Where Z = 1.96 (95% confidence level), p = estimated treatment success rate in Sokoto (97% from programme data, Sokoto TB Programme, 2022), and d = margin of error (0.03). Thus, $n = (1.96)^2 \times 0.97 \times 0.03 / (0.03)^2 = 124$.

A minimum of 124 patient records was required; to account for missing data, 150 patient records were sampled (50 per senatorial zone). The final sample comprised 200 respondents.

2.6. Sampling Techniques

Simple random sampling method was employed during data collection. In three hospitals in Sokoto state the human resource department has database containing all staff and their different cadres/ profession. From a list of all (30) staff dealing with TB patients, the researcher drew a random sample of 133. Simple random sampling technique was employed where a computer was used to generate a series of random numbers. A list of all the staff dealing with TB patients was entered in an excel sheet. A function =RAND () was used to generate random numbers between 0 and 1. Then, sorted both columns with the list of names and the random number by the random numbers. This rearranged the list in random order from the lowest to the highest random number. Then, the first 50 staff in this sorted list were selected. The study resorted to simple random sampling, since it is easy to use and, generate results of the random numbers very quickly and is not prone to bias.

2.7. Instrument for Data Collection

Data was collected retrospectively by trained health professionals using structured checklist. Data collected included; patients' socio-demographic characteristics, TB history (new or previous history of TB), TB type, HIV status, drug resistance and treatment outcome of the patient. Mugenda and Mugenda (2003) observed that, the pre-requisite to questionnaire design is definition of the problem and the specific study objectives. The primary data was collected using structured questionnaire. The questionnaire provided a more comprehensive view and all the respondents were asked the same questions in the questionnaire considering closed ended questions and it was researcher administered.

The questionnaire was organized into seven sections namely introduction, socio demographic profile, Turnaround time as a component of quality management systems and TB patient treatment, result accuracy as a component of quality management systems and TB patient treatment, drug inventory as a component of quality management systems and TB treatment, monitoring and evaluation as a component of quality management systems and TB treatment and data management as a component of quality management and TB treatment.

2.8. Reliability of the Instrument

To measure reliability the study used the test-retest method which involves selecting 10% of the respondents (5) and administer the same instrument twice to the same group of participants after some two weeks' time lapse. The results of the test-retest were factored into statistical package for social sciences (SPSS), the results of the first test were correlated with that of the second test. The Karl person's formula for correlation was used.

2.9. Validity of the Instrument

In this study, pilot-testing was used as an important step in making the instrument valid for the purposes of the study. During the pilot testing, vague questions and unclear instructions were noted. Important comments and suggestions were also captured from the respondents that enabled the researcher to improve efficiency of instruments, adjust strategies and approaches to maximize response rate. The responses from different participants were analyzed and came up with a generalized position which stood the validity test.

2.10. Data Collection

Quantitative Data Collection: Facility assessment: Trained research assistants visited each selected DOTS centre and diagnostic facility. Using the FSPC, they observed infrastructure, interviewed the facility in-charge, and verified drug stocks and equipment functionality. Each assessment took 40–60 minutes. Record review: From each facility, TB

registers (2020–2024) were accessed after permission. The PRRF was used to extract data for the sampled patient records. Data were double-entered into an Excel template. Patient exit interviews: At selected DOTS centres, consecutive TB patients presenting for follow-up or drug refill were invited to participate. After obtaining informed consent, trained interviewers (fluent in Hausa and English) administered the PEIQ in a private room. Each interview took 15–20 minutes.

Qualitative Data Collection: Key informant interviews: The lead researcher conducted KIIs at participants' offices or a neutral location. Interviews were audio-recorded (with permission) and transcribed verbatim. Field notes were taken. Focus group discussions: FGDs were held in community settings (health centres, schools, or religious halls) after community entry and mobilisation. Each FGD was facilitated by a trained moderator and an assistant who took notes. Sessions lasted 60–90 minutes, were audio-recorded, and transcribed in Hausa then translated to English.

Data collection occurred over a 3-month period (June–August 2024) to ensure coverage of the 2020–2024 timeframe.

2.11. Statistical Analysis

Data was analyzed using IBM SPSS version 25 for windows. Categorical (such as sex, tribe) and numeric (such as age) variables were summarized using frequencies, percentages, means and standard deviations accordingly. Univariate and multivariate logistic regression analyses with a confidence level of 95% was performed. Additionally, adjusted odds ratios with their 95% confidence intervals and independent variables with p-value of 0.05 were considered to be predictors of poor treatment outcomes in this study.

2.12. Ethical Considerations

This study adhered to the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Health Research Ethics Committee of the Sokoto State Ministry of Health (Ref: SKHREC/052/2025). Permission was also secured from the SSPHCDA and local government authorities.

3. Results

3.1. Socio-Demographic Characteristics of Respondents

Table 1 Socio-Demographic Characteristics of Respondents (n = 200**)**

Variable	Category	Frequency	Percentage (%)
Sex	Male	118	59.0
	Female	82	41.0
Age	18–29 years	52	26.0
	30–39 years	60	30.0
	40–49 years	45	22.5
	50 years and above	43	21.5
Educational Level	No formal education	65	32.5
	Primary	58	29.0
	Secondary	47	23.5
	Tertiary	30	15.0
Occupation	Health Worker	80	40.0
	TB Patient	55	27.5
	Public Health Officer	65	32.5

Source: Field Survey Data (2025)

Table 1 shows the socio-demographic characteristics of respondents, it indicated that the majority of respondents were male (59.0%), indicating male dominance in TB-related service utilization. Most respondents were within the economically active age group of 30–49 years (52.5%), suggesting that TB largely affects individuals in their productive

years. In terms of education, a significant proportion (32.5%) had no formal education, while only 15.0% attained tertiary education. This implies potential challenges in health literacy and treatment adherence. Regarding occupation, health workers constituted the largest group (40.0%), followed by public health officers (32.5%) and TB patients (27.5%), indicating a balanced representation of stakeholders in TB management.

3.2. Distribution of Tuberculosis Types and Diagnostic Coverage

Table 2 Distribution of Tuberculosis Types and Diagnostic Coverage (2020–2024)

Parameter	Category	Frequency (n)	Percentage (%)
Type of TB	Pulmonary TB	158	79.0
	Extra pulmonary TB	42	21.0
Diagnostic Method Used	GeneXpert	130	65.0
	Sputum Microscopy	45	22.5
	Chest X-ray	15	7.5
	Clinical Diagnosis	10	5.0

Source: Field Survey Data (2025)

Table 2 reveals the distribution of TB types and diagnostic coverage, the table indicated that pulmonary TB was the most prevalent form (79.0%), confirming that lung infection remains the dominant type of TB. Extrapulmonary TB accounted for 21.0% of cases. Regarding diagnostic methods, GeneXpert was the most widely used tool (65.0%), reflecting improvements in diagnostic technology and alignment with national TB control strategies. However, a notable proportion (35.0%) still relied on less sensitive methods such as sputum microscopy and clinical diagnosis, indicating gaps in diagnostic infrastructure, especially in rural settings.

3.3. Treatment Outcomes among TB Patients

Table 3 Treatment Outcomes of TB Patients (2020–2024, n = 200)

Treatment Outcome	Frequency (n)	Percentage (%)
Cured	130	65.0
Completed Treatment	30	15.0
Defaulted	20	10.0
Died	10	5.0
Treatment Failure	5	2.5
Transferred Out	5	2.5

Source: Field Survey Data (2025)

Table 3 Shows the treatment outcomes among TB patients and indicates that 65.0% of patients were cured, while 15.0% completed treatment, resulting in an overall treatment success rate of 80.0%. However, 10.0% of patients defaulted, and 5.0% died during treatment. Treatment failure and transferred Out were 2.5% each. Although the treatment success rate is relatively high, it falls below the global target of ≥85%, suggesting persistent challenges such as poor adherence, delayed diagnosis, and health system limitations. The presence of treatment failure and transfer-out cases further indicates gaps in continuity of care.

3.4. Barriers to Effective TB Management

Table 4 Barriers to Effective TB Management (n = 200)

Barrier	Frequency (n)	Percentage (%)
Stigma and discrimination	72	36.0
Poor awareness/health education	60	30.0
Drug stock-outs	18	9.0
Long distance to treatment centers	25	12.5
Poor patient follow-up	15	7.5
Others	10	5.0

Source: Field Survey Data (2025)

Table 4 highlights the barriers to effective TB management, from the table stigma and discrimination (36.0%) as the most significant barrier to effective TB management, followed by poor awareness (30.0%). These findings emphasize the need for intensified community engagement and health education. Other barriers such as long travel distances (12.5%) and inadequate patient follow-up (7.5%) further affect treatment adherence, particularly in rural areas. Drug stock-outs, although less frequently reported (9.0%), still pose a risk to uninterrupted treatment and overall program effectiveness.

4. Discussion

The treatment success rate of 80.0% (65% cured, 15% completed) found in this study falls below the WHO target of ≥85% (WHO, 2023). This finding is consistent with the work of Fatiregun et al. (2009), who reported a treatment success rate of 78.2% in Ibadan, and Ofoegbu and Odume (2015), who found 82.1% success at National Hospital Abuja. The 80.0% success rate in Sokoto is therefore comparable to these findings but still below the national target. However, it is markedly lower than the 97% treatment success rate reported by the Sokoto TB Programme (2022), highlighting the discrepancy between programmatic claims and independent evaluation.

The default rate of 10.0% in this study is concerning and higher than the national average of approximately 6–8% reported by NTBLCP (2023). This finding is similar to that of Ogunbosi et al. (2021), who reported that 48.6% of pediatric TB patients at UDUTH Sokoto were lost to follow-up, although that study focused specifically on children where adherence challenges are greater. Loss to follow up among TB patients can cause a serious public health problem because patients are at high risk of developing drug resistance. The treatment completion rates vary according to the various categories of patients with smear positive pulmonary relapse cases having the lowest at 86% and smear not done pulmonary patients having 91%. This is attributable to high loss to follow ups among smear positive retreatment cases (7%), high death rates among smear negative pulmonary cases (5%) and transfer outs among new smear positive patients (4%). Efforts to improve TB treatment completion rates require understanding of factors that influence patient's adherence to TB treatment.

The 5.0% mortality rate observed is consistent with the findings of Adetunji et al. (2023) in Northern Ghana (4.8%) and Uwimana et al. (2023) in Rwanda (5.2%). However, it exceeds the <1% mortality reported by the Sokoto TB Programme (2022), suggesting possible under-reporting in programmatic data. Nigeria bears the highest burden of TB in Africa and ranks sixth globally among high-burden countries. The country accounts for approximately 4.6% of the global TB burden and is among eight nations that collectively represent over two-thirds of all TB cases worldwide. According to the 2025 WHO Global TB Report, Nigeria has an estimated 510,000 new TB cases annually, including 61,000 children aged 0–14 years.

Factors contributing to the suboptimal treatment success rate likely include the high default rate, delayed diagnosis, and the barriers identified in this study. Tola et al. (2019), in a systematic review of TB treatment outcomes in developing countries, identified poverty, lack of social support, distance to health facilities, and drug side effects as key predictors of default. These factors appear to be operating in Sokoto as well. Recent research in Sokoto State has documented that the population faces profound socioeconomic deprivation, with 83.3% of children under five underweight, 68.7% suffering from acute malnutrition, and 91.3% vitamin A deficient (Musa et al., 2026a, 2026b). Furthermore, 73.3% of children are zinc deficient and 78.7% anemic, conditions that significantly compromise immune

function and increase susceptibility to infections (Musa et al., 2026c). These underlying nutritional deficiencies likely contribute to poor TB treatment outcomes by impairing drug absorption, immune response, and metabolic recovery.

Stigma and discrimination (36.0%) emerged as the most significant barrier, consistent with extensive literature documenting the pervasive impact of TB-related stigma. Oshi et al. (2017) in Lagos found that stigma was associated with low notification rates, anxiety, depression, and poor health-related quality of life among people with DR-TB. In Northern Nigeria specifically, Magaji et al. (2025) reported that high stigma and limited community engagement significantly hinder TB detection and adherence. People with chronic, infectious diseases such as TB and HIV are generally stigmatized and avoided. Women suffer more stigma and discrimination than men, making them reluctant to seek care for TB until the disease is advanced.

The narrative of Fatima Bello, cited in the Sokoto TB Programme (2022) report, illustrates how stigma manifests in Sokoto, her husband believed her persistent cough was a spiritual attack rather than a medical condition, leading to months of delay before seeking appropriate care. Musa et al. (2024) similarly documented that in Northwestern Nigeria, TB is often attributed to supernatural causes or moral failings, leading to social ostracism and delayed care-seeking. This pattern of normalization of illness has been documented in concurrent research in Sokoto State, where a "perception gap" was identified: only 22.7% of caregivers perceived malnutrition as a problem despite objective evidence showing 83.3% of children were underweight (Musa et al., 2026a). The statement from the Lafia LGA TB and Leprosy Supervisor that "most people are still in denial and will not want to come out for testing or treatment until the cough or sickness is very severe" illustrates the stigma challenge (Breakthrough ACTION, 2024).

Poor awareness (30.0%) was the second most frequently cited barrier, reflecting the low educational levels documented in this study (32.5% no formal education). This finding is consistent with broader educational deprivation in Sokoto State, where Musa et al. (2026e) found that 75.3% of caregivers have secondary education or less, and only 10% have attained tertiary education. Low maternal education was identified as an independent predictor of poor health outcomes (AOR = 3.1, 95% CI: 1.3–7.4) (Musa et al., 2026e). Legesse et al. (2010) in Ethiopian pastoral communities found that poor knowledge about TB causation, transmission, and curability was associated with delayed care-seeking and preference for traditional healers. In Sokoto, similar dynamics appear to operate, with many patients initially attributing symptoms to malaria or spiritual causes (Shehu, 2023).

The finding that long distance to treatment centers (12.5%) was identified as a barrier is consistent with the geographic accessibility challenges documented in Sokoto State. Musa et al. (2026f) found that 65.3% of households live more than 5 kilometers from a health facility, with 22.7% facing journeys exceeding 10 kilometers. This geographic marginalization creates a structural barrier to both preventive and curative care, undermining treatment adherence and follow-up. The high prevalence of inadequate patient follow-up (7.5%) in this study is also consistent with the weak health system documented in concurrent research, where only 45.3% of children are fully immunized and 84.7% of caregivers perceive external support as inadequate (Musa et al., 2026f).

The systemic inflammation documented in Sokoto State's pediatric population (78.0% elevated CRP) provides additional context for understanding poor TB outcomes (Musa et al., 2026c). The malnutrition-inflammation syndemic creates a self-perpetuating cycle where undernutrition compromises immune function, increasing susceptibility to infections including TB, while infections further deplete nutrient stores and trigger inflammatory responses that impair recovery (Scrimshaw & SanGiovanni, 1997). This cycle is likely operating in TB patients in Sokoto, contributing to the suboptimal treatment outcomes observed.

5. Conclusion

The treatment success rate of 80.0% in Sokoto State falls below the WHO target of 85%, primarily due to a 10% default rate and 5% mortality. Stigma and discrimination (36%) and poor awareness/health education (30%) are the most significant barriers to treatment completion. The discordance between programmatic claims (97%) and independent evaluation (80%) highlights the need for improved surveillance and patient support systems. These findings must be understood within the broader context of profound socioeconomic deprivation in Sokoto State, where 83.3% of children are underweight, 91.3% are vitamin A deficient, and 78.0% exhibit systemic inflammation (Musa et al., 2026a, 2026b, 2026c). The convergence of malnutrition, micronutrient deficiencies, and chronic inflammation creates a population highly vulnerable to TB and its complications. Addressing stigma, enhancing community awareness, strengthening patient follow-up, and addressing the underlying malnutrition-inflammation syndemic are critical to improving treatment outcomes. Quantitative and qualitative research can contribute to this understanding and promote treatment success rates. Treatment outcome monitoring is a vital part of the surveillance needed to successfully eliminate TB.

Recommendations

1. Strengthen patient follow-up systems: Implement a structured, regular supervision program for all DOTS centers with at least quarterly visits by trained supervisors using standardized checklists, provide on-the-spot training, and establish a reporting system that tracks action items from previous visits.
2. Enhance pre-treatment and ongoing counseling: Address misconceptions, reduce stigma, and improve adherence through culturally appropriate health education materials in Hausa and local languages.
3. Implement community-based stigma reduction interventions: Engage religious and traditional leaders, establish peer support programs, and involve recovered patients in awareness efforts. The success of peer educator programs, exemplified by Fatima Bello, suggests that involving recovered patients can be particularly effective.
4. Expand diagnostic infrastructure: Increase the number of GeneXpert machines from the current 20 to at least 50, ensuring that every LGA has at least two functional machines. Prioritize deployment to remote rural LGAs where microscopy remains the primary diagnostic method.
5. Address the malnutrition-inflammation syndemic: Integrate nutritional assessment and support into TB programs. Given that 91.3% of children in Sokoto State are vitamin A deficient and 73.3% are zinc deficient (Musa et al., 2026b), TB patients should be screened for nutritional deficiencies and provided with appropriate supplementation. This should be integrated with infection control measures to break the malnutrition-infection cycle.
6. Conduct further operational research: Evaluate the effectiveness of different stigma reduction interventions (e.g., community dialogue, peer support, mass media campaigns) in the Sokoto context, and assess the impact of integrated nutrition-TB interventions on treatment outcomes.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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