DRUG-RESISTANT TUBERCULOSIS IN NORTHERN NIGERIA: BURDEN, BARRIERS, AND HEALTH SYSTEM CHALLENGES

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ABSTRACT
Drug-resistant tuberculosis (DR-TB) remains a major public health challenge in Nigeria, especially in the northern region where weak health systems, poverty, conflict, and stigma exacerbate the problem. This review assesses the epidemiology, diagnostic landscape, treatment challenges, and health system factors influencing control of DR-TB in northern Nigeria. A systematic review on this topic was conducted on retrieved peer-reviewed articles, national reports, and other literatures from 2010 to June 2025 using PubMed, AJOL, Google Scholar, and Science Direct. Studies focusing on DR-TB epidemiology, diagnosis, treatment, and health systems in Northern Nigeria were included. Northern Nigeria shows rising DR-TB prevalence, particularly in Kano, Bauchi, and conflict-affected states. Key drivers included diagnostic delays, poor treatment adherence, drug stock-outs, and weak referral systems. While WHO-recommended diagnostic tools like GeneXpert and community-based treatment strategies are in place, access is uneven due to geographic, infrastructural, and workforce limitations. High stigma and limited community engagement further hinder detection and adherence. Health system weaknesses—such as inadequate laboratory capacity, poor funding, and weak data systems—pose significant barriers to achieving "End TB" targets. Addressing DR-TB in northern Nigeria requires a multifaceted response that goes beyond clinical care. Strengthening diagnostic infrastructure, decentralizing treatment, improving drug supply chains, enhancing community engagement, and addressing stigma are key to improving DR-TB outcomes.

Keywords: Drug-resistant TB, MDR-TB, Northern Nigeria, Health System, Diagnosis, Treatment, Stigma.

INTRODUCTION
Tuberculosis (TB), caused by *Mycobacterium tuberculosis*, remains one of the most persistent and deadly infectious diseases worldwide. According to the World Health Organization (WHO), an estimated 10.8 million new TB cases were recorded globally in 2023, with an incidence rate of 134 per 100,000 populations (WHO, 2023; Mahmud *et al*., 2025). Despite decades of global control efforts, TB remains the leading cause of death from a single infectious agent (WHO, 2023). Nigeria is one of the 30 countries with a high burden of TB, TB/HIV, and drug-resistant TB (DR-TB), with an estimated 460,000 new TB cases annually and a prevalence rate of 616 per 100,000 population (Akinyemi *et al*., 2024). In Northern Nigeria, local studies have reported even higher prevalence, with one study in Gusau showing a rate of 76.3%, largely attributed to low literacy and poor socioeconomic conditions (Musa *et al*., 2024).

A major threat to global TB elimination goals is the increasing prevalence of DR-TB—especially rifampicin-resistant TB (RR-TB) and multidrug-resistant TB (MDR-TB), defined as resistance to at least isoniazid and rifampicin (WHO, 2023). In 2019 alone, approximately 500,000 people developed RR-TB, with 78% of these cases confirmed as MDR-TB (WHO, 2020). In Nigeria, MDR-TB affects about 2.9% of new TB cases and up to 32% of previously treated cases (Onyedum *et al*., 2017). However, recent regional reports show higher rates in some states—for example, a 3.6% MDR-TB prevalence was reported in Abia State (Okorie *et al*., 2016). The WHO "End TB" strategy aims for a 50% reduction in incidence and 75% reduction in mortality by 2025 relative to 2015 levels, but only a 10% and 5.9% reduction had been achieved globally by 2021 (WHO, 2023).

MDR-TB arises from primary infection with drug-resistant strains or as a consequence of poor TB control practices—such as incorrect drug regimens, non-adherence to treatment, erratic drug supply, and lack of treatment supervision (Okorie *et al*., 2016; WHO, 2023). Inadequate diagnostic capacity contributes to under-diagnosis and delayed treatment. Although rapid molecular diagnostic tools like GeneXpert significantly reduce diagnostic timelines and improve detection (de Vries *et al*., 2017; Jiang *et al*., 2021), their availability is still limited in many resource-limited settings, including rural communities in northern Nigeria (Mahmud *et al*., 2025).
Health system constraints remain a central barrier to effective MDR-TB management. Studies have highlighted the importance of decentralization of care, short-course regimens, e-health innovations, and the involvement of multidisciplinary teams in improving treatment outcomes (Horter *et al*., 2020; Alipanah *et al*.,

2018; Baluku *et al*., 2021). Yet, systemic barriers such as inadequate training of health workers, inadequate supervision, poor salaries, high workload, and limited patient engagement continue to undermine the quality of service rendered (Mussie *et al*., 2021; Vanleeuw *et al*., 2020; Oga-Omenka *et al*., 2021).

Financing is another critical challenge to the efforts to eliminate TB. Although the WHO recommends economic support for patients in order to reduce financial barrier from accessing good health (de Vries *et al*., 2017), delays in implementing financing policies and the exclusion of second-line TB drugs from public insurance schemes significantly increase the out-of-pocket costs for patients (Zhang *et al*., 2020; Jiang *et al*., 2021).

Despite a growing body of literature on DR-TB in Nigeria, most studies have focused on epidemiological trends, access to care, or diagnostic delays (Oga-Omenka *et al*., 2019; Fadeyi *et al*., 2023). Few have critically examined the broader health system factors—such as governance, human resources, financing, and service delivery—that affect the quality of MDR-TB care. Research that captures health workers' socioeconomic factors and evaluates DR-TB interventions at the sub-national level is especially lacking (Oga-Omenka *et al*., 2019; Fadeyi *et al*., 2023).

Therefore, this review aims to synthesize available evidence on the epidemiology, treatment barriers, and health system factors influencing DR-TB care in northern Nigeria. By identifying current gaps and exploring system-level determinants of care quality, this review seeks to inform targeted policy interventions to improve TB control outcomes and align Nigeria's response with global "End TB" targets.

METHODOLOGY

Study Area

Lagend

Study area

Figure 1: Map of Nigeria Showing the Study Area

This review is focused on northern Nigeria, a vast region comprising three of the country's six geopolitical zones—North West, North East, and North Central—which together span 19 of Nigeria's 36 states and the Federal Capital Territory (FCT). This region accounts for a substantial proportion of Nigeria's landmass and population (Alhassan and Utono, 2021).

North West Zone includes Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara States. It is the most populous zone, predominantly inhabited by the Hausa and Fulani ethnic groups. The region features a Sudan savannah vegetation, a semi-arid climate, and is largely agrarian. North East Zone covers Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe States. It is characterized by Sahelian and semi-arid conditions, seasonal rainfall, and recurring humanitarian challenges such as armed conflict, displacement, and limited healthcare access—all of which significantly influence the epidemiology and control of TB and DR-TB. North Central Zone consists of Benue, Kogi, Kwara, Nasarawa, Niger, Plateau States, and the FCT (Abuja). It lies in the Guinea savannah belt, has a moderate climate, and a diverse socio-economic profile including rural and urban communities. The inclusion of all three zones offers a comprehensive overview of geographic and healthcare disparities, TB burden, diagnostic capacity, treatment coverage, and health system gaps in the management of drug-resistant TB across northern Nigeria.

Search Strategy for the Literature

A systematic search of published literatures was conducted using databases including PubMed, Google Scholar, African Journals Online (AJOL), and Science Direct. The search covered articles published from January 2010 to June 2025. Keywords and Boolean operators were used in different combinations, including "drug-resistant tuberculosis", "multidrug-resistant TB", "MDR-TB", "Northern Nigeria", "TB treatment failure", "DOTS program Nigeria", "TB health system challenges", and "TB surveillance Nigeria". In addition, reference lists of selected articles and relevant national reports were manually screened for additional sources.

Inclusion and Exclusion Criteria
Inclusion Criteria
Original research articles, surveillance bulletins, national TB reports, and systematic reviews related to DR-TB/MDR-TB in any of the 19 states of Northern Nigeria, studies reporting on epidemiology, treatment outcomes, diagnostic gaps, or health system challenges related to drug-resistant TB, and peer-reviewed publications and governmental/NGO reports with clear relevance to human TB infection were included in this review.

Exclusion Criteria
Studies not focused on Northern Nigeria, articles with insufficient data or unclear methodology on DR-TB, studies solely focused on non-human or veterinary TB strains, and non-peer-reviewed content (e.g., news reports, blog posts, or editorials) were excluded in this review.

Source of Data
The data for this review were extracted from a variety of sources, including peer-reviewed journals, National Tuberculosis and Leprosy Control Programme (NTBLCP) reports, WHO Global TB Reports, Academic theses and dissertations, Regional TB surveillance summaries, and Non-governmental organization (NGO) health sector reports

Priority was given to studies with well-defined methodologies, microbiologically confirmed cases of MDR-TB, and reports detailing treatment outcomes, drug resistance patterns, diagnostic tools used, and health system bottlenecks in TB control in Northern Nigeria.

Burden and Epidemiology of DR-TB in Northern Nigeria
Drug-resistant tuberculosis (DR-TB) remains a significant public health threat in Nigeria, particularly in the northern region, where socioeconomic disparities, limited healthcare access, and systemic weaknesses amplify disease transmission and treatment failure. The burden of DR-TB has shown a persistent upward trend due to delayed diagnosis, poor treatment adherence, and rising primary resistance (Mahmud *et al*., 2025).

Prevalence and Incidence Trends
Nigeria ranks among the 30 high-burden countries for multidrug-resistant or rifampicin-resistant tuberculosis (MDR/RR-TB), with an estimated 21,000 new MDR/RR-TB cases annually (WHO, 2023). However, only about 30–40% of these cases are detected and enrolled into treatment, with northern Nigeria consistently underperforming in case detection due to limited diagnostic access (Lawson *et al*., 2020).
A study by Gidado *et al*. (2019) showed that only 16.8% of patients tested via GeneXpert in selected northern states had MTB detected, and 6.8% were rifampicin-resistant. According to NTBLCP reports, northern states in Nigeria, such as Kano, Bauchi, Katsina, and Borno accounted for a disproportionate share of Nigeria's DR-TB burden but have limited treatment centers and GeneXpert coverage per capita (NTBLCP, 2023).
In a study conducted at the Infectious Disease Hospital in Kano, Nigeria, between 2018 and 2020, out of 2097 total tuberculosis (TB) diagnoses, 132 (6.29%) were drug-resistant TB (DRTB) cases. out of which 15 (11.36%) had MDRTB, 17 (12.88%) had Fluoroquinolone (FQ)-resistant TB, and 100 (75.76%) had other forms of DRTB (Farouq *et al*., 2022).

The total DR-TB cases seen were 53 in 2018, 51 in 2019, and 28 in 2020 (Farouq *et al*., 2022). Though, there was a significant drop in TB case detection in 2020 compared to previous years, coinciding with the start of COVID-19 transmission and control activities in Kano State. Drug-sensitive TB (DSTB) cases dropped by 66.39% in 2020 compared to 2018, and by 66.03% compared to 2019 (Farouq *et al*., 2022). In other regions, DR-TB cases dropped by 47.17% in 2020 compared to 2018, and by 45.09% compared to 2019 (WHO, 2023). Fluoroquinolone (FQ) resistant TB cases dropped by 66.67% in 2020 compared to 2018, and by 77.78% compared to 2019 (Farouq *et al*., 2022).

Onyedum *et al*. (2017) reported that, the pooled rate of any drug resistance in the northern region of Nigeria was 21.0%, which was lower than the rate in the southern region (36.0%). While, the pooled prevalence of multidrug resistance (MDR-TB) in the northern region was 3.0% which was lower than the rate in the southern region (12.0%) (Onyedum *et al*., 2017). Onyedum *et al*. (2017) also documented that, based on the reports of the previous studies, the previous rate of any resistance in the northern region was 36.0%, compared to 62.0% in southern Nigeria, while that of MDR-TB in Northern Nigeria was 26.0%, which was significantly lower than the rate in the southern region (40.0%).

Regional Distribution
DR-TB prevalence is heterogeneously distributed, often correlating with conflict zones, internally displaced populations, and states with high HIV/TB co-infection rates. For instance, Borno and Yobe states have recorded increasing DR-TB cases, partly attributed to weakened health systems following insurgency-related disruptions (Oga-Omenka *et al*., 2021). Similarly, Kano and Bauchi have emerged as regional DR-TB hotspots due to their high population density and TB caseloads.
Onyedum *et al*. (2017) emphasized that, there was a distinct pattern of lower DR-TB rates in Northern Nigeria compared to Southern Nigeria for both new and previously-treated patients.
A study by Farouq *et al*. (2022), indicated that, patients with DRTB in their study area were predominantly from northern states, with the highest numbers from Kano (59.09%), Katsina (13.64%), and Jigawa (8.33%). Other states represented included Sokoto, Kebbi, Kaduna, Bauchi, Borno, Abuja and Kogi (Farouq *et al*., 2022).

Demographic Patterns
DR-TB disproportionately affects adults in their productive years (ages 15–45), with a higher prevalence in males than females (Komolafe *et al*., 2021). Several studies have shown that men are more likely to delay seeking care, contributing to advanced disease stages and higher transmission risk. Furthermore, HIV-positive individuals are at significantly higher risk of DR-TB due to immunosuppression and overlapping stigma (Tiamiyu *et al*., 2020). Studies indicated that, the mean age of DRTB patients was 33.28 years (+/-13.264), with the majority (45.45%) being below 29 years of age (Minion *et al*., 2013), and males constituted a larger proportion of DRTB patients (63.63%) compared to females (36.37%) (Asfaw *et al*., 2010). More than half of the patients (56.06%) came from urban areas (Farouq *et al*., 2022).
Other studies revealed that, during the COVID-19 period in 2020, there was a statistically significant difference in the pattern of DR-TB presentation by gender, with females more likely to be admitted compared to males (Farouq *et al*., 2022). However, there was no statistically significant difference in presentation patterns based on age group, state of residence, setting of residence, patient type, prior second-line anti-TB use, or HIV status (Farouq *et al*., 2022).

Risk Factors and Drivers of Resistance
The primary drivers of DR-TB in Northern Nigeria include; poor adherence to first-line TB regimens, unregulated access to antibiotics and anti-TB drugs, weak contact tracing and infection control in households and facilities, delayed diagnosis due to reliance on smear microscopy in peripheral clinics, HIV co-infection, malnutrition, and poverty (Mahmud *et al*., 2025).
A recent study by Lawson *et al*. (2020) emphasized that 36% of diagnosed DR-TB patients in Nigeria are not started on treatment, largely due to referral system delays and patient refusal, often related to stigma and misinformation. Similar trend was disclosed by Farouq *et al*. (2022)
According to Farouq *et al*. (2022), the co-infection of HIV/DRTB is associated with high mortality among TB patients in northern Nigeria. Similar reports by Balabanova *et al*. (2016), Tang *et al*. (2015) and Ahuja *et al*. (2012) also emphasized the role of HIV/DRTB co-infection in the high mortality rates among TB patients in northern Nigeria.

A study Farouq *et al*. (2022) suggests that factors like male gender, and living in urban areas were more prevalent among DRTB patients. Other potential risk factors for TB acquisition and DRTB development, though not directly quantified as risk factors in their study, include cigarette smoking, seasonal migration, and poor living conditions like overcrowding (Farouq *et al*., 2022). Seasonal migrants are also more prone to interrupting TB treatment, increasing the risk of DRTB acquisition (Farouq *et al*., 2022).

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DIAGNOSTIC LANDSCAPE OF DR-TB IN NORTHERN NIGERIA
The early and accurate diagnosis of drug-resistant tuberculosis (DR-TB) is critical to controlling its spread and initiating timely treatment. In Northern Nigeria, however, diagnostic challenges remain profound. The diagnostic landscape is characterized by limited availability of modern diagnostic tools, poor laboratory infrastructure, and significant delays in case finding and confirmation. These issues collectively contribute to the under-diagnosis and continued transmission of DR-TB (Mahmud *et al*., 2025).

TB and DR-TB Diagnostic Tools in Use
Nigeria has adopted the WHO-recommended rapid molecular diagnostic tools such as GeneXpert MTB/RIF, Line Probe Assays (LPA), and liquid culture (MGIT) for the diagnosis of DR-TB. The GeneXpert MTB/RIF assay, introduced in 2011, is the frontline test for presumptive TB cases and provides results within two hours, including rifampicin resistance status (Gidado *et al*., 2019).
Despite its high sensitivity and specificity, the rollout of GeneXpert in Northern Nigeria has been limited due to inadequate machine distribution, electricity challenges, and poor sample referral systems (Lawson *et al*., 2020). Culture and DST remain largely unavailable in peripheral settings and are confined to a few reference laboratories such as those in Zaria and Maiduguri, which often experience reagent shortages and prolonged turnaround times (Adejumo *et al*., 2020).

Furthermore, Line Probe Assays (LPA), which detects resistance to isoniazid and second-line drugs, are underutilized due to cost and lack of trained personnel. Most patients with DR-TB in Northern Nigeria are diagnosed based only on rifampicin resistance without full DST coverage, which limits regimen optimization (Komolafe *et al*., 2021).

Availability and Access to Diagnostics
Access to TB diagnostic services is constrained by both geographic and financial barriers. The majority of GeneXpert machines are located in urban centers, making them inaccessible to rural populations. In many Local Government Areas (LGAs), patients travel over 100 kilometers to reach the nearest testing facility (NTBLCP, 2023).
Also, the sample transport system is fragile, with frequent delays that compromise sample integrity. Many peripheral health centers rely on smear microscopy, which cannot detect DR-TB and has low sensitivity, especially in HIV-positive patients (Tiamiyu *et al*., 2020). As a result, patients often experience diagnostic delays of several weeks to months, during which transmission continues.

Limitations in Laboratory Infrastructure
Laboratory infrastructure in Northern Nigeria is underdeveloped, with inconsistent power supply, lack of biosafety equipment, and frequent stock-outs of reagents and cartridges. Moreover, maintenance of GeneXpert machines is a recurring challenge, with many devices breaking down due to voltage fluctuations and taking months to be repaired (Oga-Omenka *et al*., 2021).
Additionally, the human resource base is weak, with few trained laboratory scientists and inadequate continuous professional development. Facilities often suffer from poor record-keeping and delays in data reporting, which affect surveillance and program planning(Oga-Omenka *et al*., 2021).

Gaps in Early Detection and Case Finding
Early case detection is crucial for controlling DR-TB transmission, yet active case finding (ACF) is rarely implemented consistently in Northern Nigeria. Many patients are diagnosed only after prolonged symptomatic periods, sometimes exceeding 6–12 months (Lawson *et al*., 2020). Household contact tracing is also poorly implemented, especially in rural or insecure areas.
There is limited integration of DR-TB screening with other services such as HIV care, maternal health, and malnutrition programs. Additionally, community awareness of TB symptoms is low, and stigma contributes to late health-seeking behavior (Oga-Omenka *et al*., 2021).

Treatment of DR-TB in Northern Nigeria

Treatment Guidelines and Regimens Used
Nigeria adopts the World Health Organization (WHO)-recommended guidelines for managing drug-resistant tuberculosis (DR-TB), which emphasize all-oral, longer regimens tailored to resistance profiles and patient conditions. The National Tuberculosis and Leprosy Control Programme (NTBLCP) introduced community-based DR-TB management in 2015 and updated treatment algorithms in alignment with WHO's 2016 and 2020 guidance (Komolafe *et al*., 2021; Gidado *et al*., 2019).
The standard longer treatment regimen used in Nigeria consists of an 18–20 month combination of levofloxacin, cycloserine, prothionamide, and pyrazinamide, with an intensive phase often including an injectable agent (e.g., kanamycin). However, the move towards all-oral regimens is ongoing, especially with the integration of bedaquiline and linezolid, in line with newer WHO recommendations (Idoko *et al*., 2022).
Patients are initiated on treatment either in health facilities or at the community level depending on disease severity and availability of services. Primary Health Care (PHC) centres and community health workers play vital roles in decentralised treatment delivery (Komolafe *et al*., 2021).

Treatment Outcomes and Success Rates
Treatment success rates for DR-TB in Nigeria vary widely depending on setting and support. A retrospective study conducted in Lagos involving 150 patients treated through community-based DR-TB care reported a treatment success rate of 70%, with 64.7% achieving good adherence and 56.5% experiencing mild adverse drug reactions (Komolafe *et al*., 2021). These outcomes are comparable to those in other high-burden countries and reinforce the effectiveness of decentralised models when adequately supported.
However, national-level data reveal substantial attrition across the care cascade. A study by Lawson *et al*. (2020) found that only 20% of estimated DR-TB cases in Nigeria are ever diagnosed, and among those diagnosed, only about 64% initiate treatment. Of those started on treatment, nearly 23% fail to complete therapy. Patients in Northern Nigeria were significantly less likely to complete treatment compared to other regions, with adjusted odds ratios as low as 0.4 for treatment success (Lawson *et al*., 2020).
In Zaria, northern Nigeria, facility-based DOTS for drug-susceptible TB patients showed a treatment success rate of 80.2% over an eight-year period (Ogbenna *et al*., 2017). Similar results were reported in Plateau State, although success rates declined in later years due to adherence challenges (Adejumo *et al*., 2020).

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Challenges in Drug Supply and Adherence

Persistent challenges in drug supply chains undermine the effectiveness of DR-TB treatment. Periodic stock-outs of essential medications and diagnostic tools, such as GeneXpert cartridges and Category I drugs, have been reported even in major treatment centres (Federal Ministry of Health, 2024). In 2024, the Federal Government acknowledged that only 37% of patients with confirmed DR-TB accessed treatment, citing systemic weaknesses in drug supply and treatment infrastructure (FMH, 2024).

Adherence remains a key determinant of treatment outcomes. Studies show that adherence above 95% is strongly correlated with treatment success, but maintaining such levels over 18–20 months is challenging. Factors such as lengthy treatment duration, adverse effects, stigma, distance to DOTS centres, and lack of psychosocial support significantly affect patient commitment to therapy (Idoko *et al*., 2022; Komolafe *et al*., 2021).

Socioeconomic constraints also play a crucial role in non-adherence. Many patients cannot afford transportation to treatment centres or face disruptions due to poor access roads, particularly in rural northern communities (Lawson *et al*., 2020).

Role of Community-Based and Facility-Based DOTS

The Directly Observed Treatment Short-course (DOTS) strategy remains the cornerstone of TB treatment in Nigeria. Facility-based DOTS is widely implemented in secondary and tertiary hospitals, but faces limitations due to bed shortages and high patient loads. These constraints led to the adoption of community-based DR-TB treatment models, particularly in Lagos and parts of the North (Komolafe *et al*., 2021).

Community-based models involve the deployment of trained health workers or volunteers to deliver medication, monitor adverse effects, and ensure adherence at the household level. This approach reduces travel burden on patients and improves retention in care. In Lagos, this model achieved a 70% treatment success rate, demonstrating its potential scalability across high-burden states (Komolafe *et al*., 2021).

Meanwhile, studies from Plateau State and Zaria confirm that well-structured facility-based DOTS can achieve high success rates, especially when accompanied by patient education and support services (Ogbenna *et al*., 2017; Adejumo *et al*., 2020).

Health System Challenges and Gaps in DR-TB Management in Northern Nigeria

The control of drug-resistant tuberculosis (DR-TB) in Northern Nigeria is heavily constrained by structural weaknesses within the health system. These challenges span across diagnostic access, treatment infrastructure, workforce capacity, surveillance, and financing—creating critical delays in diagnosis, initiation, and completion of DR-TB therapy (Mahmud *et al*., 2025).

Diagnostic and Laboratory Gaps

Despite investments in GeneXpert technology, many states in Northern Nigeria still lack sufficient diagnostic coverage. As of 2023, there were fewer than 400 GeneXpert machines available nationwide, with a large concentration in southern urban centers (NTBLCP, 2023). In remote northern areas, sputum samples often travel long distances to reach diagnostic hubs, leading to delays, contamination, or loss of specimens (Oga-Omenka *et al*., 2021).

Moreover, many peripheral health facilities rely on outdated smear microscopy, which is ineffective for detecting DR-TB. Culture and drug susceptibility testing (DST) are available only in a few tertiary centers, limiting confirmatory testing and the ability to monitor resistance trends over time (Lawson *et al*., 2020).

Human Resource Constraints

A critical shortage of trained personnel is a major bottleneck in DR-TB management. Many primary health care centers are understaffed, and the few trained TB nurses and laboratory scientists are often overburdened (Adejumo *et al*., 2020). High attrition rates, poor remuneration, and inadequate training opportunities have further weakened the health workforce in northern states.

Furthermore, frequent transfers of trained TB personnel without proper handover or replacement disrupt continuity of care. This issue is compounded by the absence of ongoing mentorship and supportive supervision, particularly in rural areas (Oga-Omenka *et al*., 2021).

Weak Referral and Follow-Up Systems

Northern Nigeria experiences systemic delays in the linkage of diagnosed DR-TB patients to treatment centers. A significant proportion of patients diagnosed with DR-TB are lost to follow-up before treatment begins. Lawson *et al*. (2020) found that approximately 36% of diagnosed DR-TB patients in Nigeria do not initiate therapy, and many of them are in the North where referral mechanisms are inefficient.

In some cases, referral facilities are located hundreds of kilometers from where patients are diagnosed, and transport costs are unaffordable. There is also inadequate coordination between the diagnostic centers and treatment sites, resulting in poor patient tracking and documentation (Komolafe *et al*., 2021).

Supply Chain Disruptions

Stock-outs of anti-TB medications, laboratory reagents, and GeneXpert cartridges have been reported across several treatment centers. These supply gaps often delay treatment initiation or force interruptions in ongoing therapy—both of which are risk factors for the development of further resistance (Federal Ministry of Health, 2024).

The logistics management system for TB commodities remains weak, particularly at state and LGA levels. Challenges include poor forecasting, delays in procurement, and weak last-mile distribution, especially in conflict-affected northern areas like Borno, Yobe, and Zamfara (WHO, 2023).

Data Quality and Surveillance Challenges

Reliable data collection and timely reporting remain a challenge in Northern Nigeria. The paper-based tools used at many DOTS sites are prone to loss, errors, and delays. Digital TB surveillance systems like e-TB Manager and DHIS2 have been rolled out unevenly, with some LGAs still lacking trained data entry staff or internet connectivity (NTBLCP, 2023).

Moreover, there is limited capacity for operational research and data analysis, leading to weak programmatic responses and poor resource allocation. For example, many DR-TB hotspots remain underreported due to poor case detection and inadequate documentation (Lawson *et al*., 2020).

Policy Framework and National Strategies for DR-TB Control in Northern Nigeria

Nigeria's national response to drug-resistant tuberculosis (DR-TB) is guided by strategic policies developed by the Federal Ministry of

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Health through the National Tuberculosis and Leprosy Control Programme (NTBLCP), in line with WHO recommendations. Despite a robust policy environment, implementation remains uneven, especially in Northern Nigeria, where conflict, poor infrastructure, and weak health systems challenge policy translation into practice.

The National TB Strategic Plan (2021–2025)
The National Strategic Plan (NSP) for Tuberculosis 2021–2025 outlines Nigeria's roadmap for ending TB as a public health problem by 2035. Its goals include achieving 100% access to quality TB diagnostics and treatment, reducing TB incidence by 50%, and strengthening multisectoral accountability (NTBLCP, 2021).

The strategy prioritizes; Integration of DR-TB services into the broader health system, decentralization of diagnostics and treatment to the community level, expansion of GeneXpert machines and lab networks, introduction of all-oral shorter regimens, including bedaquiline-based treatments, and Strengthening of private-sector engagement in TB control. However, progress has been slow in Northern Nigeria due to insecurity, weak local government health systems, and chronic underfunding (Lawson *et al*., 2020; Oga-Omenka *et al*., 2021).

Global Fund and International Donor Support
Nigeria has received significant support from the Global Fund to Fight AIDS, Tuberculosis and Malaria, the United States Agency for International Development (USAID), and the World Health Organization (WHO). These partners have provided technical assistance, GeneXpert machines, DR-TB drugs, and funding for training and community outreach programs (USAID, 2023).

In Northern Nigeria, donor-supported projects have included; mobile diagnostic vans equipped with GeneXpert, community-based treatment pilot sites, and infection control training for health workers in conflict-affected areas like Borno, Yobe, and Adamawa.

Despite donor contributions, Nigeria still faces a domestic funding gap—about 60% of the national TB response budget remains unfunded, affecting sustainability and scale-up (WHO, 2023).

Role of the NTBLCP and Federal Institutions
The NTBLCP serves as the central coordinating body for TB control in Nigeria. It is responsible for developing national policies, coordinating donor efforts, and overseeing state-level implementation. In the North, NTBLCP works with State TB and Leprosy Control Officers (STBLCOs),Zonal TB coordinators, and Implementing partners, such as KNCV Nigeria, Institute of Human Virology Nigeria (IHVN), and FHI360.However, state-level implementation is often hindered by weak health governance, poor data systems, and low political commitment. For example, several Northern states do not allocate budget lines for TB, leaving programs dependent on federal or donor support (Komolafe *et al*., 2021; NTBLCP, 2023).

National Guidelines for DR-TB Management
Nigeria has adopted WHO's latest guidelines for the treatment of DR-TB, including; the use of all-oral regimens (bedaquiline, linezolid, levofloxacin), elimination of injectable agents due to toxicity, expanded eligibility for shorter (9–12 month) regimens, regular pharmacovigilance and adverse drug reaction monitoring. These guidelines have been integrated into training manuals, standard operating procedures, and job aids for health workers.

However, uptake varies, with many facilities in the North still relying on outdated protocols due to limited training and poor guideline dissemination (Adejumo *et al*., 2020).

TB/HIV and Multisectoral Collaboration
The national TB policy promotes integration with the HIV program, recognizing the high co-infection rate. DR-TB patients are offered routine HIV testing, antiretroviral therapy, and co-trimoxazole prophylaxis.

The NSP also supports collaboration across; education (school TB screening and awareness), prisons (active screening in correctional facilities), and nutrition (support for malnourished DR-TB patients).Yet, multisectoral coordination remains weak in Northern states, where health actors often work in silos due to poor inter-agency collaboration and fragmented health financing (Lawson *et al*., 2020).

Community engagement and stigma in DR-TB control in northern Nigeria
Community engagement and stigma reduction are central to effective control of drug-resistant tuberculosis (DR-TB). In Northern Nigeria, cultural perceptions, religious beliefs, and limited awareness contribute significantly to delayed diagnosis, poor treatment adherence, and social isolation of affected individuals. Despite national strategies emphasizing community involvement, progress remains uneven, particularly in rural and underserved regions.

Stigma and Discrimination Barriers
Stigma remains one of the most persistent challenges in DR-TB control. Patients are often perceived as being "cursed" or morally responsible for their illness, leading to discrimination in families, workplaces, and communities (Oga-Omenka *et al*., 2021). This is further compounded by the association of TB with HIV, which carries its own layers of stigma.

In northern Nigeria, where strong communal ties and religious norms influence behavior, stigma can result in; Patients hiding their condition, Avoidance of health facilities, Non-disclosure to family or treatment supporters, and Refusal to initiate or continue treatment (Lawson *et al*., 2020).

Women with DR-TB may experience abandonment or divorce, while children may face bullying or school exclusion due to fear of transmission (Komolafe *et al*., 2021). These dynamics undermine both case finding and treatment outcomes.

Role of Community Structures and Leaders
Traditional and religious leaders wield significant influence in Northern Nigeria and have been recognized as critical actors in TB education and stigma reduction. Engagement of these figures in community sensitization campaigns has helped increase TB knowledge and shift attitudes in some settings (USAID, 2022).

However, this approach is not yet institutionalized across all states. In many communities, TB control is still perceived as a purely biomedical issue, handled by external health workers, with little community ownership or participation (Adejumo *et al*., 2020). This limits the effectiveness of interventions like contact tracing, treatment supervision, and patient support.

Community Health Workers and Treatment Supporters
The involvement of community health workers (CHWs) and treatment supporters is vital for patient retention and adherence. In

community-based DR-TB models in Kano, trained CHWs were tasked with; Delivering daily medications, Monitoring side effects, Providing psychosocial support, and Reporting defaulters for follow-up (Komolafe *et al*., 2021).

Patients managed under such community-supported models showed higher treatment success and better adherence. However, many CHWs are unpaid volunteers, and the absence of financial incentives or structured training undermines sustainability in the northern context (NTBLCP, 2023).

Public Awareness Campaigns

Mass communication tools such as radio jingles, community theatre, school outreach, and mobile health messaging have been used to educate the public about TB symptoms, transmission, and the importance of early treatment. These efforts are often led by implementing partners like KNCV, IHVN, and FHI360, in collaboration with state TB programs. Yet, TB awareness remains low, especially in rural northern LGAs where illiteracy is high and health-seeking behavior is shaped by cultural beliefs or spiritual alternatives. Studies have shown that a significant proportion of TB patients in the North first consult traditional healers or herbalists, resulting in treatment delays and increased risk of DR-TB (Oga-Omenka *et al.*, 2021).

Addressing Gender and Youth-Specific Barriers

Gender roles influence TB stigma and health access. Women may delay seeking care due to the need for spousal consent or fear of family rejection. Adolescents and young adults face peer-related stigma, making it difficult for them to attend DOTS clinics or disclose their diagnosis. Current TB programs lack targeted interventions for these vulnerable groups. Incorporating gender-sensitive messaging and peer support groups into TB campaigns can enhance engagement and reduce stigma-related treatment barriers (Tiamiyu *et al*., 2020).

Research gaps and innovations in DR-TB control in northern Nigeria

Despite notable efforts to expand tuberculosis control programs in Nigeria, significant research gaps remain—particularly in Northern Nigeria where DR-TB detection, treatment success, and patient retention are suboptimal. Innovative approaches and locally adapted research are urgently needed to strengthen evidence-based policy, improve outcomes, and support the achievement of TB elimination goals (Mahmud *et al*., 2025).

Limited Local Research and Surveillance Data

One of the most pressing research gaps in Northern Nigeria is the lack of subnational epidemiological data specific to DR-TB. National surveys often aggregate data, masking regional disparities and impeding targeted interventions. There is limited research on; the true prevalence of primary vs. acquired DR-TB, Community-level transmission dynamics, Risk factors specific to nomadic, rural, or displaced populations, and Resistance patterns beyond rifampicin, such as fluoroquinolone or linezolid resistance (Lawson *et al*., 2020; NTBLCP, 2023).

In addition, many studies rely on retrospective data from facility registers, which are often incomplete or poorly maintained in rural Northern states.

Need for Operational and Implementation Research

Operational research is critical for understanding the challenges and effectiveness of current interventions. However, it remains underfunded and underutilized in the region. Key gaps include; comparative studies on community-based vs. facility-based treatment outcomes in rural northern areas, evaluation of shorter DR-TB regimens in programmatic settings, impact of transport or nutritional support on adherence, and assessment of task-shifting approaches to expand DR-TB care via community health workers (Komolafe *et al*., 2021).These gaps limit policymakers' ability to optimize interventions and scale innovations based on real-world evidence.

Innovations in Diagnostics and Digital Tools

Emerging innovations such as next-generation sequencing (NGS), Xpert MTB/XDR, and whole-genome sequencing (WGS) have the potential to transform DR-TB detection. However, their application remains largely absent in Northern Nigeria due to cost, lack of technical capacity, and limited laboratory infrastructure (WHO, 2023).

Digital tools for patient monitoring and data management also offer promise. The e-TB Manager platform, DHIS2, and mobile apps for digital adherence technologies (DATs) are being piloted in some parts of the country. Still, uptake in the North is low due to poor internet connectivity, electricity challenges, and limited digital literacy among frontline health workers (NTBLCP, 2023).

Vaccine Development and Host-Directed Therapies

While TB vaccine development is an ongoing global priority, Nigeria contributes minimally to clinical trials or host-directed therapy (HDT) research. There is a need to involve northern Nigerian research institutions and teaching hospitals in multi-site studies, especially given the region's high burden and unique challenges (Mahmud *et al*., 2025).

Social Science and Health System Research

Beyond biomedical approaches, there is limited qualitative research exploring stigma, health-seeking behavior, and gender-specific challenges in DR-TB care in Northern Nigeria. Understanding these contextual factors is essential for designing culturally appropriate and gender-responsive interventions (Oga-Omenka *et al*., 2021).Additionally, health system research focusing on financing, human resource gaps, and governance bottlenecks is needed to support long-term sustainability and resilience in TB control.

Conclusion

Drug-resistant tuberculosis poses a growing threat to public health in Northern Nigeria, exacerbated by systemic healthcare limitations, inadequate diagnostics, treatment gaps, and social factors such as stigma. While national and global strategies exist, their uneven implementation across the northern region has led to persistent disparities in case detection and treatment outcomes. The challenges of delayed diagnosis, poor adherence, drug supply interruptions, and weak referral mechanisms reflect deeper structural health system issues. Without urgent, region-specific interventions, Northern Nigeria risks falling further behind in achieving global TB control targets.

Recommendations

Based on the findings of this review, several context-specific and evidence-driven recommendations are proposed to improve the

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control of drug-resistant tuberculosis (DR-TB) in Northern Nigeria:

i. Expansion of Diagnostic Infrastructure: There is a critical need to scale up the availability and equitable distribution of rapid molecular diagnostic tools such as GeneXpert and Line Probe Assays (LPA) across rural and underserved areas. Strengthening sample referral networks, ensuring consistent power supply, and maintaining laboratory equipment are essential to improving early case detection;

ii. Decentralization and Integration of DR-TB Services: DR-TB management should be integrated into primary healthcare systems and decentralized to community levels. The expansion of community-based treatment models, with adequate support for community health workers and treatment supporters, can enhance adherence, reduce default rates, and improve treatment outcomes;

iii. Strengthening Drug Supply Chains: Reliable and uninterrupted supply of anti-TB drugs and diagnostic commodities is imperative. To achieve this, the TB logistics management information system should be strengthened at federal, state, and local government levels. In addition, second-line TB medications should be included in national health insurance schemes to reduce out-of-pocket costs for patients;

iv. Capacity Building and Workforce Development: Investment in the training, retention, and supervision of healthcare workers involved in TB care is essential. Structured mentorship programs, continuous professional development, and task-shifting strategies should be implemented to address workforce shortages, particularly in remote and high-burden areas;

v. Enhancement of Surveillance and Data Management Systems: The rollout of digital surveillance platforms such as e-TB Manager and DHIS2 should be completed across all TB treatment centers, with appropriate training and infrastructure support. Operational research should be prioritized to evaluate DR-TB program performance, explore regional resistance patterns, and guide context-specific interventions;

vi. Addressing Stigma and Improving Community Engagement: TB control strategies must incorporate culturally appropriate community engagement efforts. Involving traditional and religious leaders, deploying gender-sensitive health education campaigns, and establishing peer support networks can help reduce stigma, promote timely care-seeking, and support treatment adherence;

vii. Improved Funding and Multi-sectorial Collaboration: There is an urgent need for increased domestic funding for DR-TB control programs to ensure sustainability beyond donor-supported initiatives. Furthermore, collaboration among health, education, social welfare, and other relevant sectors should be strengthened to address the multifactorial determinants of DR-TB and support affected individuals holistically..

REFERENCES

Adejumo, A. O., Daniel, O. J., Olanrewaju, J., and Olatunji, F. O. (2020). Treatment outcomes of drug-susceptible tuberculosis patients in Plateau State, Nigeria: A retrospective study. *BMC Public Health,* 20(1), 1398. https://doi.org/10.1186/s12889-020-09289-x

Ahuja S. D., Ashkin D., Avendano M., Banerjee R., Bauer M., and Bayona J. N., (2012) Multidrug resistant pulmonary tuberculosis treatment regimens and patient outcomes: an individual patient data meta-analysis of 9,153 patients PLoS medicine, 9 (8) pp. e1001300.

Akinyemi O. O., Okonkwo, T. M., and Yusuf, I. A. (2024). Statistical overview on tuberculosis in Nigeria: Epidemiological insights and public health implications. Journal of Communicable Diseases, 7(1), 45-58

Alhassan, Y.J; and Utono, M.S (2021). Economic Analysis of the Characteristics of Extensive System of Poultry Farming Enterprises In Northwestern Nigeria. International Journal of Agricultural Research and Review. 9 (3). 017–025

Alipanah, N., Jarlsberg, L., Miller, C., Linh, N. N., Falzon, D., Jaramillo, E., and Nahid, P.,(2018). Adherence interventions and outcomes of tuberculosis treatment: a systematic review and meta-analysis of trials and observational studies. PLoS Medicine, 15 (7), e1002595.https://doi.org/10.1371/journal.pmed.1002595.

Asfaw W, Tolossa D, and Zeleke G. (2010), Causes and impacts of seasonal migration on rurallivelihoods: Case studies from Amhara Region in Ethiopia NorskGeografisk Tidsskrift-Norwegian. Journal of Geography 64(1):58–70.

Balabanova Y, Ignatyeva O, Fiebig L, Riekstina V, Danilovits M, and Jaama K, (2016), Survival of patients with multidrug-resistant TB in Eastern Europe: what makes a difference? Thorax, 71(9):854–61.

Baluku, J.B., Katuramu, R., Naloka, J., Kizito, E., Nabwana, M., and Bongomin, F., (2021). Multidisciplinary management of difficult-to-treat drug resistant tuberculosis: a review of cases presented to the national consilium in Uganda. -220 BMC Pulmonary Medicine, 21 (1), 220. https://doi.org/10.1186/s12890-021-01597-1.

deVries, G., Tsolova, S., Anderson, L.F., Gebhard, A.C., Heldal, E., Hollo, V., Cejudo, L.S., Schmid, D., Schreuder, B., Varleva, T., and van der Werf, M.J., (2017). Health system factors influencing management of multidrug-resistant tuberculosis in four European Union countries - learning from country experiences. BMC Public Health 17, 334. https://doi.org/10.1186/s12889-017-4216-9.

Fadeyi, M.O., Decroo, T., Ortuno-Guti ˜ ´ errez, N., Ahmed, B., Jinadu, A., El-Tayeb, O., Adebola, W., Kehinde, A., Lynen, L., and Gils, T., (2023), A four-drug standardized short regimen for highly resistant TB in South-West Nigeria. International Health.https://doi.org/10.1093/inthealth/ihad023.

Farouq M. D., Garba I., Bashir G. A., Ibrahim A. U.,Nura M. S., Mamman B., Ibrahim M. D., Oji A., Olaoye R. and Abdulrazaq G. H., (2022), Emerging threat of drug-resistant tuberculosis and trends in the era of COVID-19: A descriptive study from northwestern Nigeria, *Journal of Clinical Tuberculosis and Other Mycobacterial Diseases* 28 (2022) 100319, https://doi.org/10.1016/j.jctube.2022.100319

Federal Ministry of Health. (2024). *Only 37% drug-resistant tuberculosis cases treated in 2024 – FG.* Nigerian Tribune. Retrieved from https://tribuneonlineng.com/only-37-drug-resistance-tuberculosis-cases-treated-in-2024-fg/

Gidado, M., Nwokoye P., Ogbudebe C., Nsa B., Nwadike P., Ajiboye P., Eneogu R., Useni S., Elom E. and Lawson A., (2019). Assessment of GeneXpert MTB/RIF performance,

Nigerian Medical Journal, 60(1), 33–39.

Horter, S., Stringer, B., Gray, N., Parpieva, N., Safaev, K., Tigay, Z., Singh, J., and Achar, J.(2020). Person-centred care in practice: perspectives from a short course regimen for multi-drug resistant tuberculosis in Karakalpakstan, Uzbekistan. -675 BMC Infectious Diseases, 20 (1), 675. https://doi.org/10.1186/s12879-020-05407-7.

Hutchison, C., Khan, M.S., Yoong, J., Lin, X., and Coker, R.J., (2017). Financial barriers and coping strategies: a qualitative study of accessing multidrug-resistant tuberculosis and tuberculosis care in Yunnan, China. BMC Public Health 17 (1), 221. https://doi.org/10.1186/s12889-017-4089-y.

Idoko, C. A., Onwujekwe, O. E., and Uzochukwu, B. S. C. (2022). Compliance of patients to DOTS tuberculosis treatment strategy in South-Eastern Nigeria: A public health concern. BMC Health Services Research, 22(1), 1094. https://doi.org/10.1186/s12913-022-08276-w

Jiang, W.X., Li, Z.P., Zhao, Q., Gao, M.Q., Long, Q., Wang, W.B., Huang, F., Wang, N.and Tang, S.L., (2021). Impacts of a comprehensive tuberculosis control model on the quality of clinical services and the financial burden of treatment for patients with drug-resistant tuberculosis in China: a mixed-methods evaluation. Infectious Diseases of Poverty 10 (1), 54.https://doi.org/10.1186/s40249-021-00832-5.

Komolafe, O. A., Gidado, M., Umoh, M., Nwokoye, N., and Ajiboye, P. (2021).Outcome of community-initiated treatment of drug-resistant tuberculosis patients in Lagos, Nigeria.Transactions of the Royal Society of Tropical Medicine and Hygiene, 115(4), 345–353. https://doi.org/10.1093/trstmh/traa150

Lawson, L., Obasanya, J., Kibirige, H., Useni, S., Odume, B., Nwokoye, N. and Gidado, M. (2020). Understanding the gaps in DR-TB care cascade in Nigeria: A sequential mixed-method study.International Journal of Tuberculosis and Lung Disease, 24(4), 402–409. https://doi.org/10.5588/ijtld.19.0591

Mahmud Z. Magaji A. and Magaji F. I., (2025), Appraisal of the Prevalence of Tuberculosis and Associated Risk Factors Among Patients Attending Healthcare Facilities in Bauchi North, Bauchi State, Nigeria, *Bima Journal of Science and Technology*, 9(1A): 255-265, 10.56892/bima.v9i1A.1252

Minion J, Gallant V, Wolfe J, Jamieson F, and Long R. (2013), Multidrug and extensively drugresistant tuberculosis in Canada 1997–2008: demographic and disease characteristics. *PLoS ONE*, 8(1):e53466.

Musa B. M., Abubakar A. U., and Lawal A. R. (2024).Prevalence, clinical characteristics, and treatment outcomes of tuberculosis in Northern Nigeria, B*MC Infectious Diseases*, 24(103), 1- 12.

Mussie, K.M., Gradmann, C., and Manyazewal, T., (2020). Bridging the gap between policy and practice: a qualitative analysis of providers' field experiences tinkering with directly observed therapy in patients with drug-resistant tuberculosis in Addis Ababa, Ethiopia. -e035272 BMJ Open 10 (6), e035272. https://doi.org/10.1136/bmjopen-2019-035272.

NTBLCP (National Tuberculosis and Leprosy Control Programme).(2023). Annual TB Programme Performance Report.Federal Ministry of Health, Nigeria.

Oga-Omenka, C., Wakdet, L. and Menzies, D., (2021).A qualitative meta-synthesis of facilitators and barriers to tuberculosis diagnosis and treatment in Nigeria.BMC Public Health, 21, 279. https://doi.org/10.1186/s12889-021-10173-5

Ogbenna, A. A., Ahmed, H., and Abdullahi, M. (2017).Tuberculosis and the determinants of treatment outcome in Zaria, Nigeria.Journal of Medicine in the Tropics, 19(2), 85–89. https://doi.org/10.4103/jomt.jomt_11_17

Okorie, O., Ahukanna, J., Gidado, M., Akang, G., Ubochioma, E., Enogu, R., Ibeziako, V., Meribole, E., and Osakwe, P., (2016). The prevalence of drug-resistant tuberculosis among people living with HIV (PLHIV) in Abia State.Advances in Infectious Diseases, 6 (2), 63–69. https://doi.org/10.4236/aid.2016.62009.

Onyedum C. C., Alobu I. and Ukwaja K. N., (2017) Prevalence of drug-resistant tuberculosis in Nigeria: A systematic review and meta-analysis, PLoS ONE 12(7): e0180996. https://doi.org/10.1371/journal.pone.0180996

Tang Y., Zhao M., Wang Y., Gong Y., Yin X., and Zhao A., (2015) Non-adherence to antituberculosis treatment among internal migrants with pulmonary tuberculosis in Shenzhen, China: a cross-sectional study BMC public health, 15(1), pp. 1-6.

Tiamiyu, A. B., Iliyasu, G., Dayyab, F. M., Habib, Z. G., Tambuwal, S. H., Galadanci, H., Bwala, S. A., Lawson, L., and Habib, A. G. (2020). Evaluation of GeneXpert MTB/RIF in patients with sputum smear-negative TB in a high HIV burden region in Nigeria. Transactions of the Royal Society of Tropical Medicine and Hygiene, 114(9), 697–699. https://doi.org/10.1093/trstmh/traa019

USAID.(2022). USAID Nigeria Tuberculosis Profile.United States Agency for International Development. Retrieved from https://www.usaid.gov/nigeria/global-health/tuberculosis

USAID.(2023). Nigeria Tuberculosis Roadmap Overview.United States Agency for International Development. Retrieved from https://www.usaid.gov/global-health/health-areas/tuberculosis/countries/nigeria

Vanleeuw, L., Atkins, S., Zembe-Mkabile, W., and Loveday, M., (2020). Provider perspectives of the introduction and implementation of care for drug-resistant tuberculosis patients in district-level facilities in South Africa: a qualitative study. BMJ Open 10 (2), e032591. https://doi.org/10.1136/bmjopen-2019-032591.

WHO (World Health Organization).(2023). *Global Tuberculosis Report 2023*. Geneva: World Health Organization https://www.who.int/publications/i/item/9789240079927

WHO, (2020), Global tuberculosis report 2020: executive summary, Geneva: World Health. https://www.who.int/publications/i/item/9789240079927

Zhang, Y., Liu, X., Yang, L., Zhang, G., Gu, Z., Chen, Z., and Sun, J., (2020). Barriers and strategies: a review of access to affordable multi-drug resistant tuberculosis medication in China. Infection and Drug Resistance, 13, 3679–3687 https://doi.org/10.247/IDR.S256128.