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The Bidirectional Relationship Between Diabetes and Tuberculosis in Nigeria: Epidemiological Insights and Control Strategies

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ABSTRACT

Nigeria faces a double burden of tuberculosis (TB) and diabetes mellitus (DM), creating a syndemic in which DM increases the risk of active TB and worsens TB outcomes, while TB and its treatment can destabilize glycaemic control and unmask previously undiagnosed DM. Nationally, adult diabetes prevalence is substantial with a very high proportion undiagnosed, while TB incidence remains among the highest in Africa. Nigerian facility data show (i) high DM prevalence among TB patients and a large "additional yield" of newly diagnosed DM when systematic screening is implemented, and (ii) frequent dysglycaemia (DM/prediabetes) at TB diagnosis with performance limitations of point-of-care HbA1c in program settings. This review synthesizes Nigeria-relevant epidemiology, mechanisms of bidirectionality, diagnostic challenges, and practical integrated control strategies aligned with WHO guidance and Nigeria's National Strategic Plan (NSP), emphasizing bidirectional screening, integrated clinical workflows, and health-system strengthening.

Keywords: tuberculosis, diabetes mellitus, Nigeria, bidirectional screening, HbA1c, fasting plasma glucose, integrated care, NTBLCP

INTRODUCTION

Tuberculosis (TB) control is increasingly shaped by the rising burden of non-communicable diseases (NCDs), particularly type 2 diabetes mellitus (DM). This overlap is not coincidental: TB and DM interact bidirectionally in ways that heighten clinical risk, complicate care pathways, and increase health-system costs. In response, the World Health Organization (WHO) issued a collaborative TB–DM framework emphasizing coordinated programmatic and clinical action: (i) functional collaboration between TB and DM services, (ii) improved detection and management of TB among people with diabetes, and (iii) improved detection and management of diabetes among TB patients [1]. Mechanistically, diabetes increases susceptibility to active TB through impaired innate and adaptive immune responses, and when glycaemic control is poor, is linked to higher bacillary burden, delayed sputum conversion, and greater risk of unfavourable TB outcomes. Conversely, TB infection and inflammation can disrupt glucose homeostasis, unmask previously undiagnosed diabetes, or trigger transient hyperglycaemia, thereby complicating diagnosis and treatment decisions [2]. These biological and clinical interactions translate, at the service-delivery level, into more clinic visits, additional laboratory monitoring, prolonged recovery, and greater exposure to catastrophic health expenditure, especially in low- and middle-income settings where TB remains endemic, and diabetes detection is weak. Nigeria is a priority context for TB–DM integration because it carries a large dual burden alongside a substantial reservoir of undiagnosed diabetes, creating a "perfect storm" for missed opportunities in bidirectional screening and timely linkage to care [3]. Although national policy documents increasingly recognize TB comorbidity with NCDs, implementation gaps such as limited guideline development and inconsistent routine screening persist. Collectively, these realities justify focused research on how TB–DM collaborative activities operate in practice in Nigeria, particularly the effectiveness of bidirectional screening and continuity of care [4].

Despite clear global guidance and national recognition that TB and diabetes worsen each other's outcomes, TB–DM collaborative activities in Nigeria are not yet consistently implemented at the point of care. A major barrier is the large pool of undiagnosed diabetes in the population—approximately four out of five adults with diabetes may not know their status. In this context, TB clinics may treat patients whose uncontrolled or undetected

hyperglycaemia increases the risk of delayed response and unfavorable outcomes, while diabetes clinics may miss TB among symptomatic patients until disease is advanced and transmission has occurred [5].

Programmatic documents underscore that, even with the known TB–DM relationship, gaps persist, such as limited operational guidance and uneven integration of comorbidity management within routine TB services. Consequently, Nigeria risks a cycle where diabetes continues to silently fuel TB incidence and poor TB outcomes, while TB-related stress hyperglycaemia and undiagnosed diabetes remain unmanaged, undermining progress toward TB control targets and increasing preventable morbidity, costs, and health-system strain [6].

What remains insufficiently documented and therefore difficult to improve is the real-world performance of bidirectional TB–DM screening and linkage to care: Who is being screened, how consistently screening is done, what proportion of additional TB–DM cases are identified through screening, and what happens after diagnosis (referral completion, treatment initiation, and continuity of care). Without this evidence, integration remains a policy aspiration rather than a measurable, optimizable service package [7].

This study aims to assess the uptake and diagnostic yield of bidirectional TB–DM screening among adult patients attending selected TB and diabetes care settings in Nigeria. Its significance is multi-layered. Clinically, evidence on screening uptake and yield will guide early identification of diabetes among TB patients and TB among diabetes patients, enabling timely glycaemic control, treatment optimization, and improved TB treatment response, aligning with WHO priorities for collaborative TB–DM care. From a public health perspective, strengthening detection of TB in high-risk groups such as people with diabetes can reduce diagnostic delays and community transmission, while early diabetes diagnosis within TB services can address an important upstream driver of TB risk and poor outcomes. At the health-system and policy level, the findings can support practical operationalization of TB–DM integration by informing refinement of standard operating procedures, strengthening referral pathways between TB and NCD services, and targeting essential commodities and algorithms (e.g., glucometers/strips, symptom screening tools, and diagnostic workflows) where they deliver the highest yield. Economically and equitably, opportunistic screening may provide a cost-efficient entry point to uncover undiagnosed diabetes and prevent expensive late TB presentations, improving allocation of constrained program resources. Finally, the study will close Nigeria-specific evidence gaps and guide follow-on implementation research on barriers, linkage-to-care, and quality improvement.

Epidemiological Insights in Nigeria

Facility and program data from Nigeria show a consistent, operationally important overlap between tuberculosis (TB) and dysglycaemia/diabetes mellitus (DM). In a 2015 multicentre implementation across 13 facilities in six southern states, 9.4% of TB patients had DM, and 5.5% were newly identified through clinic-based screening. Screening produced a high "additional yield" (59%), with an overall number needed to screen (NNS) of 18 to detect one new DM case, lower still among older adults, highlighting TB clinics as efficient entry points for uncovering Nigeria's large reservoir of undiagnosed DM [8]. Evidence from Oyo State DOTS centres (2022) reinforces this pattern beyond tertiary hospitals: among 404 TB patients, 7.9% had DM, and a further 7.4% had impaired fasting glucose, signalling a sizeable "prediabetes" pool for prevention and early risk modification. In Abuja district hospitals, among 410 presumptive TB adults with complete culture and glycaemic data, 15.1% had DM and 11.2% had prediabetes at evaluation; importantly, DM remained independently associated with TB after adjustment (AOR 3.10). However, the poor agreement of a point-of-care HbA1c device with the reference platform underscores that test quality and validation matter. Nationally, Nigeria's TB NSP (2021–2026) estimates ~14,000 TB cases (~3%) attributable to DM, supporting bidirectional screening as a strategic program response [9].

Bidirectional TB–Diabetes Interaction: Immunopathology and Clinical Implications

Diabetes mellitus (DM) increases susceptibility to tuberculosis (TB) via intertwined defects in host immunity and disease progression, making the elevated TB risk clearly multifactorial. Persistent hyperglycaemia compromises innate immune defenses by impairing macrophage and neutrophil function, key cells for phagocytosis, oxidative burst activity, and intracellular killing that normally provide early containment of *Mycobacterium tuberculosis* [10]. When these first-line mechanisms are blunted, initial control is weaker, facilitating progression from infection to active disease. DM also disrupts adaptive immunity, with altered T-cell responses and dysregulated cytokine signaling; because durable TB control depends on coordinated T-cell–mediated immunity that sustains granuloma formation and integrity, DM-related immune shifts can destabilize granulomas and reduce the host's capacity to sequester bacilli [11]. Clinically, DM is consistently linked to higher bacillary burden, more extensive disease, and poorer treatment responses, strengthening the case for routine bidirectional screening and integrated TB–DM care. Nigeria-relevant evidence reinforces this biologic plausibility: in Abuja, DM showed an independent association with culture-positive TB even after adjustment, suggesting the relationship extends beyond confounding and aligns with underlying immunopathology. Conversely, TB can worsen glycaemic control and sometimes "unmask" DM through stress hyperglycaemia driven by systemic inflammation, counter-regulatory hormone surges, and catabolic states (weight loss and muscle wasting) [12]. Reduced oral intake and erratic nutrition further complicate glucose-lowering therapy, while drug effects and interactions, particularly with rifampicin, may alter the metabolism of some

antidiabetic agents and destabilize glycaemic control. Programmatically, this explains why hyperglycaemia detected at TB diagnosis may be transient in some patients, yet also why TB-clinic screening can reveal substantial previously undiagnosed DM in Nigeria.

Diagnosis Challenges in Nigerian Healthcare Settings

Diagnosis of diabetes mellitus (DM) within Nigerian healthcare settings is complicated by both population-level underdetection and facility-level test constraints, with direct consequences for TB–DM integration. Nationally, a large share of people living with DM remain undiagnosed, meaning many tuberculosis (TB) patients present to TB clinics without any prior knowledge of their glycaemic status unless TB services implement routine DM screening. Choosing the right diagnostic test then becomes an operational challenge [13]. Fasting blood glucose/fasting plasma glucose (FBG/FPG) is relatively practical and widely available, but it requires fasting, often unrealistic in congested clinics and difficult for acutely ill TB patients. HbA1c is operationally appealing because fasting is unnecessary, yet its use is limited by quality concerns: point-of-care HbA1c devices may produce unreliable results when not locally validated, as suggested by Abuja findings showing weak agreement with reference platforms. In addition, anaemia and haemoglobinopathies common in many low- and middle-income settings can distort HbA1c interpretation. A pragmatic Nigerian approach is therefore tiered: use FBG where fasting can be reliably achieved, use laboratory HbA1c only where strong quality assurance exists, and avoid unvalidated point-of-care HbA1c for diagnosis unless locally verified. Compounding these issues are TB diagnostic bottlenecks; continued reliance on smear microscopy and uneven access to rapid molecular testing can delay or miss TB diagnoses, weakening integrated TB–DM care, as reflected in Oyo State where smear microscopy remained the dominant primary PTB test [14].

Integrated Management: What "Good" TB–DM Care Looks Like

Good integrated TB–DM care means one clinic visit, two conditions managed, with shared workflows, data, and follow-up. WHO's collaborative framework emphasizes bidirectional screening plus coordinated clinical management at the point of care, and Nigeria's National Strategic Plan (NSP) aligns with this by calling for systematic diabetes screening in TB services and routine TB screening in diabetes clinics [15]. In a Nigeria-ready bidirectional model, the highest-yield entry point is DOTS/TB clinics: every TB patient should receive fasting blood glucose (FBG) or HbA1c where quality is assured at registration/early treatment, with a pragmatic repeat test later (e.g., near the end of the intensive phase) to distinguish stress hyperglycaemia from true diabetes. Local evidence supports this approach, showing a high DM prevalence among TB patients and substantial additional yield of previously undiagnosed DM (reported NNS ≈18 in Southern Nigeria). The reverse pathway is often missed: diabetes clinics should apply a brief TB symptom screen at each visit (cough ≥2 weeks, fever, night sweats, weight loss) and refer promptly for GeneXpert/Truenat where available. Co-management then requires anticipating unstable glycaemia during TB therapy, tailoring nutrition to balance TB wasting with diabetes constraints, monitoring drug–drug interactions (notably rifampicin effects), and strengthening adherence support to reduce default amid high pill burden and long treatment duration [16].

Control Strategies for Nigeria: A Practical Roadmap

Nigeria needs a practical TB–DM control roadmap anchored in policy + service integration between the National TB, Leprosy and Buruli Ulcer Control Programme (NTBLCP) and NCD programs. First, embed TB–DM indicators into routine reporting, including the proportion of TB patients screened for DM, DM clinic attendees screened for TB symptoms, and TB treatment outcomes stratified by DM status [17]. Second, adopt nationally standardized bidirectional screening algorithms, leveraging Nigeria's NSP justification that DM is a recognized TB risk factor and that systematic screening is recommended. Third, formally engage private hospitals, clinics, and pharmacies in the same screening and reporting framework, given evidence of higher DM prevalence among TB patients managed in private facilities in Southern Nigeria. Diagnostics should be strengthened by expanding rapid TB tests (e.g., GeneXpert/Truenat) supported by functional specimen referral networks, alongside strict quality assurance for glycaemic testing especially where HbA1c is used, since Abuja findings highlight risks from unvalidated point-of-care HbA1c. Implementation can be accelerated through low-cost workflow redesign: train TB clinic teams to screen/referral for DM, and introduce one-stop "TB–DM days" with shared registers, counselling, and synchronized follow-ups. Finally, prioritize older and rural TB cohorts, while intensifying TB prevention within DM care through symptom screening, IPC in waiting areas, and optimized glycaemic control [18].

Research and Implementation Gaps

Key research and implementation gaps remain for tuberculosis–diabetes mellitus (TB–DM) comorbidity in Nigeria. First, the country lacks nationally representative estimates of TB–DM burden; most evidence comes from facility-based cohorts that may over- or under-estimate prevalence because they miss people who do not access care, those treated in the private sector, and populations with different risk profiles [19]. Second, the optimal DM diagnostic strategy for TB patients is still uncertain under real-world Nigerian constraints: fasting blood glucose (FBG), HbA1c, and repeat testing have different costs, logistics, and accuracy issues in the setting of acute TB illness, anemia, and limited laboratory capacity, making it unclear which approach best balances feasibility and validity.

Third, there is limited evidence on the cost-effectiveness of bidirectional screening (screening TB patients for DM and DM patients for TB), particularly in primary care and private facilities where a large share of Nigerians seek services. Finally, Nigeria needs integrated care trials that go beyond detection to test coordinated TB–DM service delivery models, measuring TB treatment outcomes, glycaemic control, and patient-level economic endpoints, including catastrophic health expenditures, to guide scalable policy and financing decisions [20].

CONCLUSION

Nigeria's TB–DM comorbidity agenda is constrained more by evidence and delivery gaps than by lack of clinical rationale. The current literature is dominated by facility-based cohorts, leaving Nigeria without nationally representative estimates of TB–DM burden and risking biased prevalence inferences that exclude underserved, private-sector, and higher-risk groups. Diagnostic uncertainty further weakens implementation: FBG, HbA1c, and repeat testing each face feasibility and validity trade-offs in routine Nigerian TB care, complicated by acute infection effects, anemia, and limited laboratory capacity. Beyond detection, the policy case for bidirectional screening remains incomplete because robust cost-effectiveness data, especially from primary care and private facilities, are scarce. Critically, Nigeria now needs integrated care trials that evaluate real-world TB–DM service delivery packages, not just screening yields. Such trials should measure TB treatment outcomes, glycaemic control trajectories, and patient-level economic impact, including catastrophic health expenditure. Addressing these priorities will enable evidence-based guidelines, smarter financing, and scalable models that reduce missed diagnosis, improve outcomes, and protect households from avoidable costs.

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