2024 Emory Morningside Global Health Case Competition

Tackling India's Twindemic: Accelerating integrated diabetes mellitus-tuberculosis care to end TB

EMORY UNIVERSITY

Emory Global Health Institute

2024 Emory Morningside Global Health Institute Case Writing Team

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Introduction

Prime Minister, Honorable Narendra Modi has set an ambitious goal to achieve tuberculosis (TB) elimination in India by 2025, five years ahead of the global action pledge to end TB by 2030. The interaction between diabetes mellitus (DM) and TB, however, presents a challenge for this accelerated timeline and threatens progress toward TB elimination if these co-epidemics are left unmitigated.

India has the highest burden of TB globally, with 2.4 million cases reported in the National TB Program of India in 2019.[1] Concurrently, the prevalence of DM has increased in both rural and urban areas, escalating from 2.4% and 3.3 %, respectively, in 1972, to 15% and 19%, respectively, in 2019.[2] This escalation in DM prevalence adds complexity to TB control and elimination efforts as DM increases the risk of active TB and the probability of adverse TB treatment outcomes such as failure, death and recurrent TB. Integrated case management and care for patients with TB and DM poses an additional challenge due to the interaction between anti-TB drugs and diabetes medications, potentially leading to treatment complications and poorer health outcomes for patients. Researchers have delved into the interacting comorbidity that links TB and DM for years, seeking to understand, mitigate, and ultimately resolve the challenges posed by these dueling diseases.

Sadar Hospital is a high-volume public healthcare institution in Samastipur, a city in Bihar State, serving as a lifeline for its community. The number of patients seeking care exacerbated with ongoing issues of inadequate infrastructure and limited financial and human resources, impacts the hospital's ability to provide timely and comprehensive care. Amidst these challenges, Dr. Ravi Pathak, a final-year postgraduate medical student, shoulders the responsibility of providing care in the bustling outpatient department (OPD).

On a hectic summer morning in the OPD, a patient named Kishor Mishra arrives with complaints of a persistent cough, fever, weakness, thirst, weight loss, and blurry vision spanning 5 to 6 weeks. During intake, Kishor, a man in his forties, tells Dr. Pathak that he is struggling to navigate his life. Kishor's family lacks the resources to sufficiently provide him with a safe space to live. Following his release from prison, he divides his time between a cramped two-room apartment shared with family members and short-term homeless shelters. Crowded cohabitation presents a heightened risk of exposure to TB through insufficient hygiene, which allow *mycobacterium tuberculosis* to spread, as well as the use of crowded facilities by others who are recently released from prison, homeless, or injection drug users— all high-risk populations for TB transmission. Kishor, therefore, finds himself in conditions that increase his risk of exposure to the infectious disease.
Dr. Pathak informs Kishor that he suspects he may have an active case of TB given his symptoms and risk factors for exposure to TB. Dr. Pathak orders a chest X-ray and collects a sputum sample, which comes back indicative of an active TB infection.

The positive TB test results leads to a referral to the Directly Observed Therapy (DOT) center, and Kishor is sent home with TB medications. Kishor indicates that although he frequently moves from one place to another, he will try his best to complete his prescription.

Two months later, Kishor returns to see Dr. Pathak with a persistent cough, a positive sputum culture, and X-rays displaying scarring, opacification, and visible nodules in his lungs— all findings indicative of severe, active TB. Kishor also complains of numbness and slowly healing skin sores on his feet. Dr. Pathak begins to suspect Kishor may also have DM and explores the potential connection between TB and DM. Dr. Ravi calls for further tests. The complete diagnosis unfolds—a case of active TB exacerbated by undiagnosed DM.

TB Alert India, a group dedicated to addressing TB and DM comorbidity in India since 2000, collaborates with Dr. Hassan Sharma, Dean of Sadar Hospital, in response to concerns raised by Dr. Pathak about the hospital's standard of care for cases such as Kishor's. Dr. Sharma acts quickly to create a task force comprised of researchers and staff from TB Alert India. The task force assesses the awareness among healthcare workers of TB-DM infections as well as diagnostic and care protocols. The findings highlight a critical need for improved awareness, education and adherence to guidelines outlined in the National Framework for Joint TB-DM Collaborative Activities. Despite efforts to circulate and implement these guidelines, around 80% of healthcare workers remain unaware of the protocols, in particular guidance to conduct random blood sugar tests for patients presenting with TB symptoms—an aspect of comprehensive care outlined in the Framework.

The findings from the task force assessment motivate TB Alert India to conduct evaluations in states across the country. They direct their attention to a hospital in Kerala to perform a similar assessment. In contrast to Bihar State, Kerala State in southwestern India has relatively robust socioeconomic indicators and a well-developed health system. TB Alert India engages in comprehensive evaluations to assess awareness of TB-DM care among healthcare workers. Despite advancements in TB screening and reporting, the assessment concludes that awareness of TB-DM care among healthcare workers in the state remains disconcertingly low. Despite regional disparities, a pervasive lack of awareness about TB-DM care persists. The findings from these two geographically and economically distinct states highlight critical gaps that must be addressed to accelerate integrated diabetes mellitus-tuberculosis care and progress toward the ambitious goal of TB elimination by 2025.

Disclaimer: All characters described within the case are fictional, but the background information provided in the case report reflect real-life data and events ongoing in India. Teams are responsible for justifying the accuracy and validity of all data and calculations that they use in their presentations.

Case Prompt

In response to this research and given the national goal of ending TB, The Ministry of Health and Family Welfare (MoHFW), under the Government of India (GoI), collaborates with the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS), and The National Tuberculosis Elimination Programme (NTEP), to form a consortium. This consortium has decided to fund state TB-DM integrated care programs. Given the national goal to end TB by 2025, the partnership will provide funding to local non-governmental organizations (NGOs) to partner with states and other entities to develop innovative and sustainable interventions to accelerate integrated TB-DM care programs, especially those designed to reach and serve populations most at risk of infection and adverse health outcomes.

The consortium has published a request for proposals for a five-year $7 million program.

NOTE: *In 2021, the GoI convened national workshops for states and union territories to develop their State Strategic Plans for ending TB by 2025, five years ahead of the Sustainable Development Goal (SDG) target of 2030. While prioritizing the government's ambitious timeline for TB elimination in India, a successful proposal will present an evidence-based approach for improving TB-DM integrated care by 2030.*

The consortium prioritizes proposals that fulfill the following criteria:

a. Applicants choose one of India's 28 states to implement the intervention. They must provide a detailed overview of the chosen state's geographic, cultural, socioeconomic, linguistic, and healthcare needs, as well as elucidate how specific TB/DM manifest in the region. For guidance in selecting the state, refer to maps illustrating geographic variations of TB and DM in India, available in the Background section.

b. Interventions must address the bidirectional relationship between diabetes mellitus and tuberculosis, detailing the problem identification and reason for chosen interventions. They must also recognize and integrate the role of the private health sector in proposed solutions, given the large proportion of the population using private services in several states. Consideration should be given to how the principles of the social determinants of health impact TB-DM health outcomes. It is crucial to reference the National Framework for Joint TB-DM Collaborative Activities published by GoI, as it provides valuable insights [accessible at https://tbcindia.gov.in/].

c. Proposals should include at least one technology solution that addresses the gaps present in India's current joint TB-DM guidelines, considering local factors such as cultural characteristics and geographical conditions, and prioritizes resource efficiency.

d. Budgets should be the $7 million envelope and include a detailed breakdown by year, with itemization of costs for personnel, supplies, etc., over the five-year period of the award.

e. Proposals should include a comprehensive five-year timeline of all components of the proposed activities.

f. Proposals should include a sustainability plan that ensures continuity of solutions beyond the funding period and describes how the project builds capacity in the selected state beyond the funding period.

g. Proposals should include a monitoring and evaluation (M&E) plan that specifies project indicators and methods for assessing impact. All measures for data to be collected should be justified in relation to the project's intended goal.

DELIVERABLES

You are a local/state NGO, consisting of an interdisciplinary team of public health, medical, legal, business, administrative, and research personnel. Your proposal will be submitted in the form of a **twelve-minute presentation** to the panel of reviewers including representatives from MoHFW, GoI, NPCDCS, NTEP, the private sector, community members, and health workers. It is imperative to include your NGO's name and information about established partnerships and stakeholder relationships in your chosen geographic area.

Components of your submission should include:

A. **Power Point Presentation:**
   1) Title of the proposal
   2) Project narrative:
      a. Description of the problem you intend to address
      b. Description of the intervention(s)
      c. Supporting evidence, with citations, about why you chose this specific approach
   3) Five-year timeline plan
   4) Budget
   5) Sustainability Strategy
   6) Monitoring and Evaluation (M&E) Strategy

B. **Executive summary of your proposed recommendations (one-page document)**

TIMELINE

From Thursday, March 14, 12:00 PM ET until Thursday, March 21 at 1:00 PM ET, teams are welcome to contact the Case Writing Chair to ask questions or seek clarifications about the content of the case. Questions will **not** be accepted after 1:00 PM ET on **Thursday, March 21**. Questions should be emailed to Case Writing Chair, Ketki Vinayak Joshi, at ketki.vinayak.joshi@emory.edu. Through Wednesday, March 20, the Case Writing Chair will respond **within 12 hours** of receipt of a question. Starting Thursday, March 21, responses to team questions will be sent within **3 hours** from the time they are submitted. To ensure that teams have similar knowledge about the case, all questions and answers will be posted on the competition site via a Google document link.

BACKGROUND

Global Burden

The COVID-19 pandemic significantly impeded access to TB diagnosis and treatment, leading to a marked escalation of the global TB disease burden. In 2021, around 10.6 million individuals worldwide were diagnosed with TB, marking a notable increase from 10.1 million in 2020. Moreover, the number of TB-related deaths increased to approximately 1.6 million in 2021, showing a 14.1% increase compared to 2020. Despite these alarming figures, progress towards the World Health Organization's (WHO) End TB Strategy 2025 milestone remains limited, with only a 10% reduction in TB incidence and a 5.9% reduction in TB deaths observed between 2015 and 2021.[3]

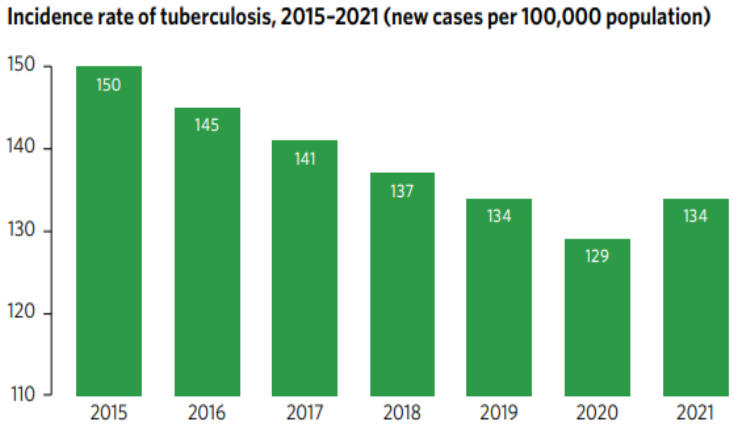


Image source: The Sustainable Development Goals Report 2023

Around 460 million people were living with diabetes in 2019, per the Global Burden of Disease (GBD) estimates, making the disease the 8th leading cause of death and disability combined globally. The below figure shows the prevalence of diabetes by age and GBD region in 2021 and shaded areas show 95% uncertainty intervals.[4]

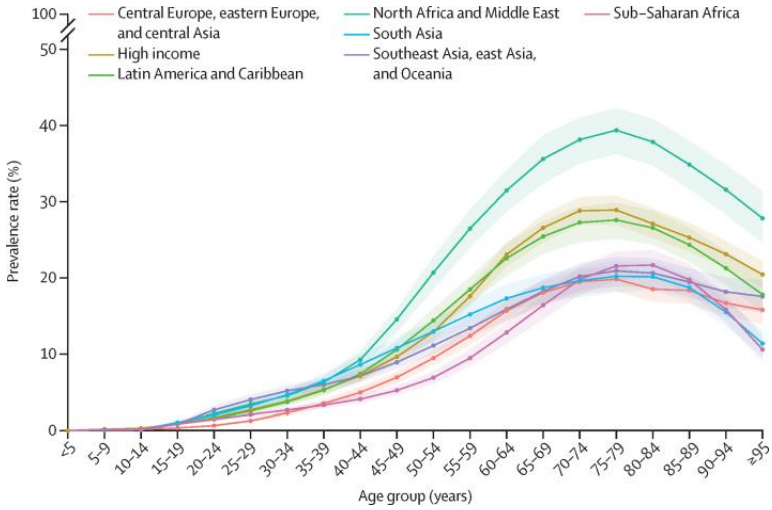


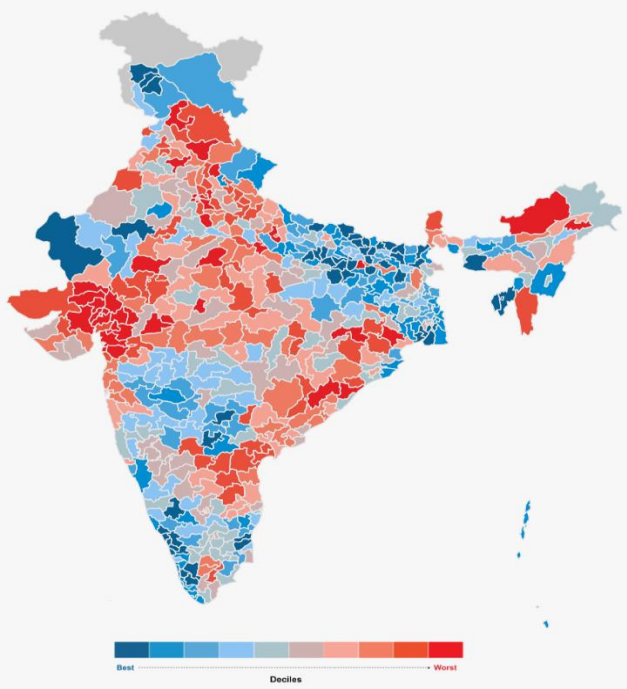
Image source: Global Burden of Diseases, Injuries, and Risk Factors Study, 2021

Additionally, the global dual burden of tuberculosis (TB) and diabetes mellitus (DM), particularly prevalent in middle-income countries (MICs), poses a critical public health challenge due to the potentially high prevalence of TB–DM comorbidity. The highest TB burden countries in the world, accounting for over 50% of the estimated prevalence of TB worldwide, are India (26%), China (8.5%), Indonesia (8.4%), Philippines (6.0%), Bangladesh (3.6%) and Nepal (0.45%). The prevalence of DM among the adult population is 10.4% in India, 9.2% in Bangladesh and in China, 7.2% in Nepal, and 7.1% in the Philippines. Indonesia has the lowest DM prevalence at 6.2%.[5]

National Burden

In 1997, the GoI initiated the National Tuberculosis Elimination Programme (NTEP), aimed at achieving a significant decline in the burden of TB in India. This initiative has successfully saved 7.75 million lives from 1997 to 2016.

However, there are almost 2.4 million notified cases of TB, making India, with a population of 1.4 billion people, the country with the highest burden of TB.[6] Additionally, India is recognized as the “Diabetes Capital of the World”. DM accounts for 75 million cases in individuals aged 20 years and above as of 2021.[7]



Geographic variation of TB metrics [Harvard University Center for Geographic Analysis.(n.d.). India TB. Retrieved from https://geographicinsights.iq.harvard.edu/IndiaTB.]
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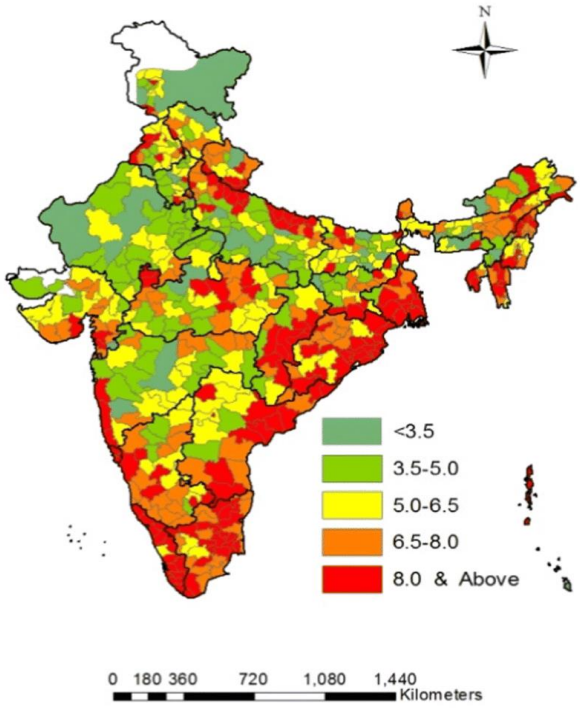

District-wise prevalence of diabetes among adults(case notifications per 100,000) (aged 15–49 years), National Family Health Survey (NFHS-4)

TB-DM Burden

In India, the integrated care of TB and DM is constantly evolving, bringing with it both opportunities and challenges. Research has shown that among patients with TB in India, the prevalence of DM ranges from 12.39% to 44%. The southern states have reported the highest prevalence with a range of 25.3% to 44%, while the northern states have a range of 12.8% to 15.8%. Of the 28 states in India, Kerala had the highest prevalence of DM among TB patients, accounting for 44%, while Madhya Pradesh had the lowest prevalence at 12.39%. Pulmonary TB patients who have diabetes generally exhibited lower cure rates and poorer treatment outcomes when compared to those without DM.[6]

In areas of India with strong healthcare facilities, local governments take an active part in combating TB and provide substantial patient support. Areas with limited funding and governmental commitment find it difficult to treat TB/DM patients effectively. While some regions successfully incorporate private sector providers in tuberculosis control, others have notable gaps in the participation of private practitioners. In some areas, there are well-defined procedures for TB/DM case detection, while insufficient testing facilities and integration provide challenges in other areas. In certain regions, decentralized and integrated care systems guarantee efficient TB/DM patient monitoring, whereas others lack integration and mostly depend on specialist referrals. The need for enhancing training for healthcare professionals is evident to improve TB/DM diagnosis and treatment.[6]

TUBERCULOSIS AND DIABETES MELLITUS

Tuberculosis

TB is an airborne disease caused by the bacterium *Mycobacterium tuberculosis complex* and has been described as early as 3,000 years ago.[8] In 2019, 1.3 million people died as a result of TB compared to 2.3 million in 2005. Deaths attributed to TB have been on the rise since 2020, possibly due to increasingly disparate access to healthcare and other inequities resulting from the COVID-19 pandemic.[9]

Latent TB

Most individuals infected with TB are in the latent stage of infection for anywhere from weeks to decades before progressing to the active stage. Latent TB is known as a subclinical infection, as affected individuals do not experience any associated symptoms. Estimates show that approximately one-third of the world's population harbors latent TB infection. Activation of latent TB infection is more likely in immunocompromised people, those with co-morbidities like diabetes, and individual and systemic risk factors like alcoholism, substance abuse, smoking, and indoor air pollution.

Active TB

The clinical presentation of active TB infection typically includes fever, chronic cough lasting more than three weeks, night sweats, weight loss, and sputum production. The manifestation of active TB infection in patients with DM appears to be slightly different and is dominated by fever and hemoptysis (coughing up blood). Furthermore, while active TB is usually identified in the upper lobes of the lungs, it is commonly found in the lower lobes in patients with DM.

Diagnosis and Treatment of TB

Tuberculosis can be diagnosed in several ways, including chest radiography, sputum culture, and molecular assays. These diagnostic tools range widely in terms of cost, rapidity, and sensitivity (ability to accurately detect disease).[10] Treatment for TB is relatively standardized around the world and entails directly observed therapy (DOT), whereby a trained health worker provides anti-TB medication to the patient and individually observes them taking the pills. Given the rise in multidrug-resistant (MDR) strains of TB, the standard first-line therapy for TB is being closely examined for effectiveness, particularly in patients with co-morbidities.[11] The novel drug bedaquiline has become a standard first-line treatment for MDR cases of TB.

Diabetes Mellitus

Diabetes mellitus (DM), also called diabetes, is a chronic metabolic disease characterized by elevated levels of blood glucose, also known as hyperglycemia.[12] There are two main subtypes of DM – Type 1 and Type 2 – which result from insufficient production (Type 1) or action (Type 2) of the hormone insulin. Patients with Type 1 diabetes are typically born with the disease. Type 1 diabetes is characterized by the destruction of pancreatic beta cells due to autoimmune deficiency, which decreases the cells' ability to secrete insulin. Those with Type 2 diabetes are likely to have experienced obesity, poor nutritional status, sedentary lifestyle, and/or stress, all of which can lead to chronic hyperglycemia, thereby impairing pancreatic beta cells and decreasing the functionality of insulin. Both Type 1 and Type 2 diabetes can lead to serious complications if left untreated or poorly managed, including cardiovascular disease, kidney failure, nerve damage, vision problems, and lower limb amputations.

Treatment of DM

Treatment of diabetes is complex and varies by subtype; however, all patients with DM, regardless of subtype, are initially urged to make substantial changes to their diet and lifestyle by restricting their caloric and carbohydrate intake and exercising regularly. Patients are recommended to regularly self-monitor their blood glucose levels with a glucose monitor and attend regular check-ups with their primary physician or endocrinologist. At these visits, patients typically undergo several screenings, including a hemoglobin A1c (HbA1c) test, which is used to diagnose and track an individual's DM status over time.

Recommended therapeutics for patients with Type 1 DM include supplemental insulin and/or oral anti-hyperglycemic agents, the latter of which fall into seven main classes: 1) biguanides; 2) sulfonylureas; 3) DPP-4 inhibitors; 4) thiazolidinediones; 5) SGLT-2 inhibitors; 6) alpha-glucosidase inhibitors; and 7) non-sulfonylurea secretagogues.[14] While some patients with Type 2 DM can manage their condition solely with dietary and lifestyle changes, oral anti-hyperglycemic agents and/or insulin can be added to their treatment regime to supplement these modifications if needed (depending on individual HbA1c levels.)

In India, an estimated 74.9 million people were living with DM in 2021.[13] Without further intervention or programmatic change, this number was projected to increase to 124.9 million by 2045.

Non-adherence to DM Treatment

Symptomatic control of DM is threatened by non-adherence to treatment, which remains one of the most common reasons for poor health outcomes among patients with DM.[15] Treatment non-adherence has been documented to range worldwide between 23% and 77% among patients with Type 1 DM, with higher rates in low- and middle-income countries.[16]
An exploratory study conducted in a tertiary hospital in Rishikesh, Uttarakhand, India found that nearly 50% of patients with uncontrolled Type 2 DM delayed initiating insulin therapy. Participants cited barriers to treatment adherence such as financial cost; medical mistrust; lack of knowledge about DM and the benefits of treatment; living far away from a healthcare facility; underestimations of the severity of one's disease; and societal stigmas.[17]
Other factors cited as barriers to DM treatment adherence include a lack of family and social support, conflicts between treatment and work schedules, and fear related to previous adverse events in the family.[18]

Non-adherence to TB Treatment

Failure to adhere with TB treatment can lead to various complications, spanning from disease relapse to potential fatality.[19] TB treatment involves a drug regimen that lasts for six months. The extended duration of TB care is the primary cause of non-adherence to treatment. Numerous factors contribute to nonadherence: clinical factors, such as medication side effects and improved symptoms; psychosocial factors, such as alcohol use and social stigma; structural barriers, such as geographic distance from healthcare facilities, migration patterns, and employment challenges; and health system barriers, such as uncooperative staff and inadequate medication supplies.[20]

TB and Diabetes Association

The risk of active TB infection in patients with DM is two to four times the risk of TB in individuals without DM.[9] [10] Existing research points to the deleterious effects of chronic hyperglycemia on cellular integrity and immune health, which then predispose patients with DM to TB infection and a higher bacterial load, possibly worsening outcomes and complicating treatment options. Before insulin became the most popular medication to treat DM, TB was among the most common

causes of death among patients with DM. While screening for DM among TB-infected patients is highly recommended, the availability of diagnostic tools depends largely on local resources, access, and community awareness of the dual burden of disease.

First-line TB therapy has been found to have adverse effects on glycemic control, thus putting patients with DM at a greater risk of poor health outcomes. Lifestyle changes such as diet modification and nutritional supplementation, moderately intensity exercise, and smoking cessation can help improve health outcomes related to DM and TB. Aggressive pharmaceutical treatment of DM in co-morbid patients can also have benefits for TB outcomes.

According to the WHO, in 2018, approximately 400,000 people with diabetes became infected with TB worldwide. The dual burden of TB and DM has prompted efforts around the world to tackle the twin epidemic. However, systemic risk factors for TB such as overcrowding, indoor air pollution, and migration have challenged national governments and public health systems.

There is a bidirectional relationship between TB and DM. The figure below shows that initiating TB treatment by itself lowers blood sugar levels, in different strata of DM treatment (or lack thereof).

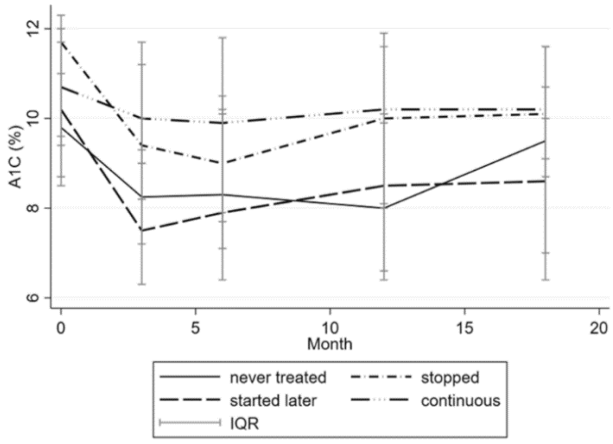

Image Source: Kornfeld H, Procter-Gray E, Kumpatla S, Kane K, Li W, Magee MJ, Babu S, Viswanathan V. Longitudinal trends in glycated hemoglobin during and after tuberculosis treatment. Diabetes Res Clin Pract. 2023 Feb;196:110242. doi: 10.1016/j.diabres.2023.110242. Epub 2023 Jan 7. PMID: 36627027.

Additionally, in a recent study by Geeta Pardeshi et al., hyperglycemia treatment prevents unfavorable TB outcomes (TB treatment failure, TB recurrence, and all-cause mortality).

Reciprocal Relationship of TB and DM

TB usually occurs due to exposure to another person with contagious pulmonary TB. Initially, most patients are asymptomatic and go into a latency period that may last from a month to years before some develop active TB disease. Globally, there are more than a billion people with latent TB infection; most live in India and China. Diabetes, malnutrition, steroid therapy, HIV, and other immunosuppressing conditions lead to an increased risk of TB reactivation. The rise in DM cases around the world, especially in resource-limited countries, is threatening the WHO End TB Strategy by 2030. Simultaneously, TB increases the risk for DM and other forms of hyperglycemia, rendering the relationship between those two diseases reciprocal.

The management of hyperglycemia among people with TB lacks clear guidance. Early in its course, TB is associated with stress-induced hyperglycemia, in patients with or without known DM at baseline. That dysregulation in glucose metabolism is associated with worse TB treatment outcomes, but also with short-term complications of hyperglycemia (diabetic ketoacidosis, hyperosmolar hyperglycemia, etc.), requiring urgent healthcare visits and, in some cases, admission to a hospital.

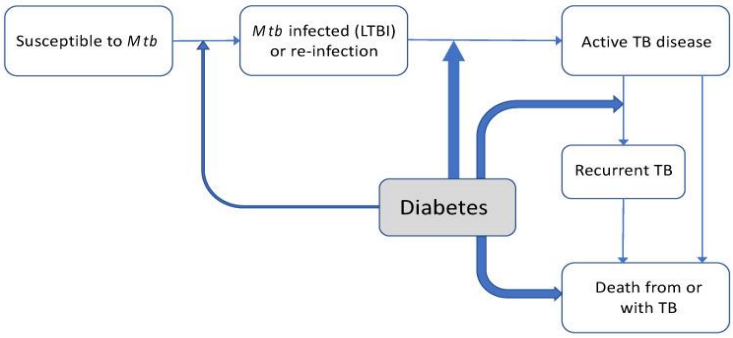

Image source: van Crevel R, Critchley JA. The Interaction of Diabetes and Tuberculosis: Translating Research to Policy and Practice. Trop Med Infect Dis. 2021 Jan 8;6(1):8. doi: 10.3390/tropicalmed6010008. PMID: 33435609; PMCID: PMC7838867.

The image above illustrates the reciprocal relationship of tuberculosis and diabetes and is supported by the following points:

- Populations and related risk factors
    - Patients with diagnosed TB and DM
        - Approximately 1.5 million globally are affected simultaneously by TB and DM (WHO Global Tuberculosis Report 2021).
    - Patients with diagnosed diabetes, at risk for TB
        - The risk of active TB infection in DM patients, a disease characterized by hyperglycemia, or increased blood glucose levels, is two to four times the risk of TB in individuals without DM. In 2020, an estimated 370,000 (UI:

150,000 – 680,000) new cases of TB were attributed to diabetes (WHO Global Tuberculosis Report 2021).

- Patients with diagnosed TB, at risk of developing diabetes
  - A systematic review and meta-analysis of data from 2.3 million people with TB worldwide estimated that the prevalence of DM in patients with TB is around 15%.
  - Chronic hyperglycemia (diabetes) has been implicated in decreased cellular and immune health, increasing the risk of TB infection.
- Patients with diagnosed diabetes and latent TB
  - Malnutrition is a risk factor for the progression of latent TB to active TB.
  - Other risk factors for activation of latent TB include immunodeficiency, malignancy, smoking, alcohol and other substance abuse, and indoor air pollution.
- Patients who are positive for TB and Diabetes, but undiagnosed/screened

CONTEXTUAL LANDSCAPE OF INDIA

India Population: 1.438 billion, according to World Population Review 2024 (the most populous country in the world)

Demographics: 28 states and 8 Union Territories
India exhibits a demographic distribution characterized by 40 cities surpassing a population of one million. 396 cities falling within the range of 100,000 to 1 million inhabitants, and 2,500 cities sustaining populations ranging from 10,000 to 100,000. Mumbai, the largest city in India, accommodates a populace of 12,691,836 individuals followed by Delhi with a population of 10,927,986.[21]

Malnutrition and Its Relation to TB and DM

Malnutrition stands as the primary risk factor contributing to TB incidence, especially severe undernutrition, which increases mortality among TB patients in the country. However, the influence of nutritional supplementation on TB incidence remains uncertain, with limited studies exploring its impact on TB mortality through food rations, on TB incidence among a high-risk group—household contacts (HHC) of individuals diagnosed with microbiologically confirmed pulmonary TB (PTB) in Jharkhand.[22]

Despite the risks of undernutrition and its risk for TB mortality, other studies have examined the relationship between malnutrition as it relates to DM and TB. The analysis of the interplay between diabetes and body mass index (BMI) concerning active tuberculosis in a South Indian cohort revealed a notable prevalence of diabetes among patients with active TB across varying BMI levels. Malnutrition, indicated by BMI, was linked to a higher TB burden, particularly among individuals without diabetes. Interestingly, BMI and diabetes were not identified as significant risk factors for latent TB infection (LTBI) in representative samples.[23]

Urbanization contributes the most to malnutrition issues in India due economic disparities. High consumption levels of animal-based products, refined animal fat, edible oil, refined sugar, and alcohol characterize diets in urbanized societies with higher economic development. Studies show that urbanizing countries are rapidly converging to these diets, increasing human health risks related to conditions such as obesity and hypertension, and non-communicable diseases such as diabetes, heart disease, and stroke. Additionally, results show that infrastructure, market access, the percentage of working women in urban areas, and norms and institutions have a statistically significant influence on dietary habits and food access.[24]
Access to food is crucial for maintaining a healthy and sustainable diet. A study conducted in Mumbai examined the informal food network in a sample area. The number of vendors varied from one locality to another, the southern part of the city, which is primarily commercial, had fewer informal vendors compared to the northern or suburban parts of the city.[25] This disparity in the number of vendors servicing different areas of the city can result in some citizens being more at

risk of food deserts based on their location within the city, income inequalities, hygiene, and supply and demand.

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Weather Patterns and Related Impact on Public Health Efforts

India is subject to a yearly monsoon season. The Indian summer monsoon typically lasts from June-September, with large areas of western and central India receiving more than 90% of their total annual precipitation during the period, and southern and northwestern India receiving 50%-75% of their total annual rainfall.[26] Although monsoon season is a well-established weather pattern, as climate shifts globally, Indian weather patterns have become more unpredictable and violent than in decades past. Repeat flooding has caused an average value of 255 billion rupees ($3.7 billion U.S. dollars) in housing, crops, and infrastructure damage. Data shows that in recent decades, there has been a threefold increase in widespread extreme precipitation events over central India.[27]

Aside from the severe, widespread displacement of peoples from their homes and the resultant crowded temporary housing, this displacement can exacerbate both TB and DM in vulnerable populations. *Mycobacterium tuberculosis*, the bacteria which causes tuberculosis infections, can live for almost two months without a human host in ideal standing water conditions, creating a breeding ground for infection. Therefore, displaced peoples can find themselves at risk of infection both from strangers living alongside them in temporary housing and the surrounding environment. In addition to this risk of TB, the destruction of immediately available local food sources and loss of personal items like diabetes monitoring supplies increase the difficulty of living safely diabetes through monitoring and insulin level management. Those who are living through natural disasters with active diabetes and those who have prediabetes are equally at risk of inability to monitor and manipulate their insulin levels during displacement.

Political Implications

India operates as a federal parliamentary democratic republic with a multi-tiered government system comprising the central government and individual state governments. The central government, led by a Prime Minister and a President as the ceremonial head of state, functions in New Delhi. Its policies are devised based on a constitution that emphasizes fundamental rights,

individual freedoms, and social justice. Economically, India boasts a mixed economy, with agriculture, manufacturing, and services sectors contributing significantly. The country has experienced rapid economic growth in recent decades, although income inequality remains a persistent challenge. India is culturally diverse, home to various religions including Hinduism, Islam, Christianity, Sikhism, Buddhism, and others, fostering a rich tapestry of religious practices and traditions coexisting within a secular framework, ensuring freedom of religion for its citizens. With India's political system in mind, barriers arise when implementing effective policies for TB and DM mitigation. In 2017, India launched a collaboration to eradicate TB-DM through a national framework. Despite its noble mission, the policy has struggled to fully integrate its approach at the policy level due to various factors.

1.) Limited Awareness: A lack of awareness among healthcare professionals and the public about the correlation between TB and diabetes. This hampers early detection and proper management of both diseases.

2.) Diagnostic Challenges: Difficulty in diagnosing both TB and diabetes in a timely and accurate manner poses a significant challenge. Access to quality diagnostic facilities, especially in rural areas, remains limited.

3.) Treatment Coordination: Coordinating treatment protocols for patients with both TB and diabetes is complex. Ensuring adherence to multiple medication regimens and managing potential drug interactions can be challenging. Maintaining the continuity of care is difficult when patients are at chronic risk or fail to adhere to treatment education from providers.

4.) Healthcare Infrastructure: India's vast and diverse healthcare infrastructure often struggles with inadequate resources, staffing, and infrastructure, particularly in rural areas, impacting the effective management of TB and diabetes.

5.) Stigma and Social Factors: Stigma associated with TB and misconceptions about diabetes often lead to delayed diagnosis and treatment. Social factors such as poverty, malnutrition, and living conditions exacerbate the prevalence of both diseases.

Stratification of Social Groups and Ethical Considerations

Certain populations are at heightened risk of transmitting and contracting TB. These groups include prison populations, homeless persons and/or those who frequent shelters, pregnant populations, multigenerational/multi-family housing, and injection drug users.[32] Many of these population groups are frequently socioeconomically disadvantaged and medically underserved. It is imperative to anticipate and address the ethical implications of conducting research and implementing programs for these groups. These populations "are vulnerable in research either because they have difficulty providing voluntary, informed consent arising from limitations in decision-making capacity … or situational circumstances …, or because they are especially at risk for exploitation."[33]

Low literacy in these groups, especially low health literacy, is frequently an obstacle to obtaining true informed consent in healthcare programming. Informed consent is a complex process that includes “providing a potential participant with adequate information to allow for an informed decision about participation in the clinical investigation; facilitating the potential participant's understanding of the information; an appropriate amount of time to ask questions and to discuss with family and friends the research protocol and whether you should participate; obtaining the potential participant's voluntary agreement to participate; and continuing to provide information as the clinical investigation progresses or as the subject or situation requires.”[34] Although a team's intervention may not be medically novel, programming must consider the ability of a patient to meaningfully and autonomously consent to participation in the program.

Exploitation of vulnerable populations is also a concern. Considerations to investigate the potential for exploitation of a patient include asking “how the power differential between the subject and the investigator is being addressed, if economic issues might place subjects at risk for undue inducement, and if the recruitment process and payment arrangements are acceptable.”[35] Because the above populations are at heightened risk of both TB infection and exploitation, teams must consider the balance between facilitating recruitment for their program and respecting the power dynamic of the public health professional/patient relationship.

Because these population groups are frequently socioeconomically disadvantaged, teams must consider and address the capacity of their intervention to use resources to encourage patient participation which is motivated by a patient’s understanding of the risks and benefits and their desire to be treated, rather than motivation by financial assistance or a misconception of the program itself. Deliverables that include patient education resources, appropriate financial compensation for participants where applicable, and efforts to ensure realistic patient expectations of their healthcare outcomes following participation will be favored.

State of Health Care and Accessibility for Low-income Populations in India

India's healthcare system is often cited as a prime example of universal healthcare services in a large and economically diverse country. Structured across three tiers, it aims to ensure that government healthcare services reach households in both urban and rural areas, free of charge or at a minimal cost. Each state in India manages its own healthcare delivery system, comprising both private and public sectors. While states have primary responsibility for their healthcare systems, the central government plays a key role in funding national healthcare programs, coordinating efforts across regions, and shaping policies.[36]

In urban areas, a network of 1083 urban family welfare centers and 871 health posts serve as primary sources of healthcare, particularly for the urban poor and those in slum areas. Additionally, hospitals provide primary healthcare services alongside more specialized care. On average, each urban health post caters to approximately 62,603 individuals, while urban family welfare centers serve around 48,557 people.[37]

According to the World Bank, India allocated 4% of its GDP to healthcare expenditure in 2013, with public funds contributing 31.1% of the total healthcare expenditure. However, despite these investments, significant challenges persist in ensuring equitable access to healthcare for urban populations, particularly the marginalized and economically disadvantaged.

Government facilities are less expensive for patients and are staffed by qualified and expert personnel, but most households tend to use private providers, who are not only unregulated but also often unqualified.[37] According to the Central Bureau of Health Intelligence report and Murray's study[38]:

- Healthcare services in India are disproportionately concentrated in urban areas and the private sector.
- Urban residents (28% of the population) have access to 66% of hospital beds, while rural residents (72% of the population) have only one-third of the beds available to them.
- Healthcare workers, including doctors, nurses, and pharmacists, are also concentrated in urban areas and the private sector.
- Patients in rural areas face challenges in accessing healthcare facilities due to long distances, with 63% having to travel more than five kilometers for inpatient care.
- Private healthcare costs are 2 to 9 times higher than public facilities, posing affordability challenges for patients. However, private healthcare facilities are increasingly utilized due to gaps in quality and availability of public facilities.
- The reasons for selecting private health care facilities in urban areas include 62% doctor availability in the private sector, 56% to get quick access, 54% less waiting time, 26% not free medicines in the governmental sector, 16% can afford, and 13% lack of specialist in public sector.

Current Policies and Gaps

“India’s Revised National TB Control Program (RNTCP), now known as National Tuberculosis Elimination Program (NTEP) evolved as one of the world’s largest public health programs that has saved at least 7.75 million lives between 1997 and 2016.”[39] Although an integrated detection and care framework for TB and DM has been established in India, it is in its early phase. Common obstacles for expansion of the system providing for TB/DM interaction in patient populations are a lack of universal perception of TB/DM comorbidity as a public health issue, supply chain, human resources, and training needs within the systems.[6] Other obstacles to public health interventions generally applying to community participation, transregional equity in access to care, and difficulties implementing WASH strategies in socioeconomically disadvantaged communities are also present.

Since the COVID-19 epidemic, TB numbers in India have risen 19%. The NTEP reports that one of its current innovations is technological advancement and application: “capitalizing on Artificial Intelligence (AI) for improving healthcare delivery, increasing diagnostic accuracy, and screening for disease, an AI solution is being developed to screen for TB from cough sounds and voices.” Another success in India is that “As a result of TB-Diabetes collaborative framework

implementation, nearly 93% of the TB Detection Centres have blood sugar testing facilities."[40] However, detection of diabetes is only the first step to management, and TB Detection Centres do not provide treatment of both conditions.

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