# An Epidemiological Analysis of Tuberculosis in Maharashtra, India

Mamatkulova Nazgul Mamatkulovna[1]*, Vicky Kumar[1], Prashad Bhalaerao[1], Ashok Kumar[1], Uday Krishna[1], Bikram Shaw[1]

[1]Mamatkulova Nazgul Mamatkulovna, PhD, Teacher of Public Health Department, International Medical Faculty, Osh State University

***Corresponding author:** Mamatkulova Nazgul Mamatkulovna
Mamatkulova Nazgul Mamatkulovna, PhD, Teacher of Public Health Department, International Medical Faculty, Osh State University

| Abstract | Original Research Article |
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Tuberculosis (TB) is an extremely serious public health issue in India where the highest number of TB cases is reported worldwide. Maharashtra, one of the most populated and economically important states in India, plays a major role in this national burden. This study makes a thorough academic investigation into the tuberculosis situation in Maharashtra and looks into epidemiological patterns, demographic and socio-economic factors, the increasing problem of drug resistance and the state's response through the National Tuberculosis Elimination Programme (NTEP). The analysis which is based on data from government reports, international health databases, and recent studies points out urban conglomerates such as Mumbai, particular high-risk groups such as migrants and industrial workers, and the epidemics connection with non-communicable diseases as the epidemic's main triggers. The conclusion of the paper is that Maharashtra has made great progress in case notification and treatment initiation, but elimination targets can only be met by 2025 through intensified, multi-sectoral efforts such as active case finding in high-risk groups, strong infection control, comprehensive management of drug-resistant TB, and dealing with the social determinants of health. The results emphasize the requirement for a specific, data-driven strategy for TB control in a state where there are huge contrasts between urban wealth and poverty, and between fast economic growth and health inequities that persists.

**Keywords:** Tuberculosis, Maharashtra, National Tuberculosis Elimination Programme (NTEP), Drug Resistance, Urbanization, Socio-economic Factors.

## 1 INTRODUCTION

Tuberculosis (TB), which is attributed to the bacterium Mycobacterium tuberculosis, is a disease that comes from antiquity and is still regarded as a global health hazard. The year 2022, saw a total of around 9.6 million TB cases as well as 1.3 million deaths making it the world's second-largest infectious killer after COVID-19 (WHO, 2023). India has the lion's share of the tuberculosis burden, accounting for roughly 27% of the planet's new TB cases. The government's ambitious National Strategic Plan to eliminate TB (less than 1 case per 100,000 population) by 2025; a target that surely requires a detailed understanding of the disease at the sub-national level.

Maharashtra, which is located in the central-western part of India, is the second-most populous state and a key economic driver for the country. It has a population of over 120 million people, different types of geography including major cities and tribal areas, and various patterns of migration, which makes it a very important and challenging battlefield in the war on TB.

The state is always among those reporting the highest TB cases in India. Maharashtra had more than 230,000 new and relapse TB cases reported in 2022, which was a large part of the national figure (Central TB Division, 2023).

The end of TB in Maharashtra cannot be solely attributed to the large population of the state. It has become part and parcel of the socio-economic situation in the state. The cities of Mumbai, Pune, and Nagpur have witnessed the rise of slum areas due to rapid urbanization, which is mostly unplanned, and these slum areas are now the major sites for the spread of the disease through the air. The state of Maharashtra has also become a hotspot of internal migration with a big influx of workers from other states looking for jobs in the construction, manufacturing, and services sectors. This population has limited access to healthcare and is, therefore, highly prone to disease. In addition, the increasing number of diabetics and those who smoke is a major risk factor which angry the infection and the death of the ill patient.

This study adopts the IMRaD (Introduction, Methods, Results, and Discussion) for- mat of scientific writing for a thorough, data-driven, and well-evidenced analysis of tuberculosis in Maharashtra. Its purpose is to:

1. Present the existing epidemiological profile and the trends of TB in the state.
2. Examine the demographics, clinic, and economic factors that are most significant in shaping the epidemic's trajectory.
3. Measure the state's achievements with respect to the NTEP and point out the areas still in need of attention.
4. Reflect on the particular problem of drug-resistant TB (DR-TB).
5. Put forward evidence-based recommendations for quicker achievements in the journey towards the eradication of TB.

## 2 METHODS

This analysis stems from a comprehensive review and meta-synthesis of secondary data from varied sources including governmental and international health agencies, peer- reviewed academic literature, and programmatic reports. The primary sources of epidemiological data consist of:

• **India TB Report 2023 & 2024:**

These are the most reliable annual accumulations of programmatic data from the National Tuberculosis Elimination Program (NTEP) published by the Central TB Division, Ministry of Health and Family Welfare, Government of India.

• **Global Tuberculosis Reports (2022, 2023):**

WHO's reports that give away the global and regional estimates, including the one for India.

• **Maharashtra State TB Cell Reports:**

Data is collected from the state's health department in the form of operational data and bulletins.

• **Peer-reviewed journals:**

For literature, searches were performed on databases like PubMed, Google Scholar, and Scopus with the use of keywords like" Tuberculosis Maharashtra,"" Drug-resistant TB Mumbai,"" NTEP Maharashtra," and" TB urban slums India." To secure the relevance of the articles to the current epidemiological context, only the last decade articles were selected for consideration.

The quantitative data regarding case notifications, treatment outcomes, and drug resistance patterns were extracted from the previous reports for the purpose of data analysis. The analyzed trends covered a five-year period (2018-2022) where data was consistent. Descriptive statistics are shown in tables, and a pie chart that shows the composition of drug-resistant TB cases has been created. The interpretations are based on a comparison with the national averages and the stated programmatic targets.

The limitations of this analysis are that it is based on reported programmatic data, which, in the case of drug-resistant forms, may suffer from under-reporting or diagnostic gaps. Private sector case notifications, even though they are included in the NTEP through mandatory notification laws, may still be incomplete. The sociological and qualitative insights into care-seeking behavior are based on existing literature and may not reflect all local nuances.

## 3 RESULTS

### 3.1 Epidemiological Burden and Trends

Maharashtra continues to be one of the leading states in India in terms of TB cases. The state's case notification rate (CNR) per 100,000 residents has experienced variations due to increased active case-finding measures and the effect of the COVID-19 pandemic.

**Table 1: Tuberculosis Case Notification in Maharashtra vs. India (2018-2022)**

| Year | Maharashtra Total Notifications | Maharashtra CNR (per 100,000) | India Total |
|------|--------------------------------|-------------------------------|-------------|
| 2018 | 218,188 | ~172 | 2,15 |
| 2019 | 234,557 | ~184 | 2,40 |
| 2020 | 199,463 | ~155 | 1,62 |
| 2021 | 217,969 | ~168 | 2,11 |
| 2022 | 231,169 | ~178 | 2,42 |

*Source: Compiled from India TB Reports 2020-2024.*

**Explanation of Table 1:**

Table 1 reveals that Maharashtra's CNR has been always above the national average during the whole period, which is indicative of the higher detected burden. The very noticeable decline in 2020 for both Maharashtra and India can be interpreted as the pandemic's COVID-19 major impact on TB services, which led to the aforementioned situations of lockdown, healthcare facility diversion, and patient unwillingness to come forward for care. It is very clear that the recovery in notifications has occurred by 2022, with Maharashtra nearly reaching the levels of pre-pandemic again. Nevertheless, the CNR being consistently higher than the average is an indicator that Maharashtra is a state that requires priority in the fight against TB.

## 3.2 Demographic and Clinical Profile

The condition strikes the economically productive age groups most heavily. Almost 70% of the reported cases come from the 15-59 age group. The ratio of male to female among the registered patients is usually around 65:35, which is a pattern also observed nationally, and this might be due to biological factors, higher exposure among men, and gender differences in access to healthcare being the reasons.

The co-epidemic of tuberculosis (TB) and non-communicable diseases (NCDs) is a significant worry and one that is steadily getting bigger. Diabetes is the main risk factor that almost triples the possibility of getting active TB and at the same time, it is one of the main reasons for poor treatment outcome. In Maharashtra state, TB patient screening has shown that the prevalence of DM in some urban areas is more than 20%, which is significantly higher than the average for the entire country (Singla *et al.,* 2019). Likewise, tobacco consumption and undernutrition are still two comorbid conditions that are very common.

## 3.3 Geographic Heterogeneity and Urban Challenge

The burden is not the same everywhere. Major urban agglomerations, especially the Mumbai Metropolitan Region (MMR), are the infection's epicenters. The city of Mumbai alone accounts for a large percentage of the TB cases in the whole state. The slums of Mumbai, which are very densely populated, have poor housing conditions and none or very little ventilation thus more so the transmission happens. Research done in a Mumbai slum found that the annual transmission rate was 4.6%, which is one of the highest rates ever documented in the world (Nair *et al.,* 2020). Other districts with high TB burden are Pune, Thane, Nagpur, and Nashik, which are also urban-industrial centers.

## 3.4 The Drug-Resistant TB Landscape

Drug-resistant tuberculosis, especially Multidrug-Resistant tuberculosis (MDR-TB—resistant to both isoniazid and rifampicin), poses a serious danger to the TB control measures implemented. Maharashtra has to deal with a huge problem of drug-resistant TB.

**Table 2: Drug-Resistant TB in Maharashtra (2022)**

| Parameter | Number | Percentage/Remark |
|---|---|---|
| Total DR-TB Patients Notified | 7,842 | – |
| MDR/RR-TB Patients | 6,458 | 82.4% of total DR-TB |
| Pre-XDR TB Patients | 1,192 | 15.2% of total DR-TB |
| XDR-TB Patients | 192 | 2.4% of total DR-TB |
| Treatment Success Rate (MDR/RR-TB cohort 2021) | 73% | (National avg: 76%) |

**Source:** India TB Report 2024, Central TB Division.

**MDR/RR-TB:** Multidrug or Rifampicin-Resistant TB; Pre-XDR TB: MDR-TB with additional resistance to a fluoroquinolone; XDR-TB: MDR-TB with additional resistance to a fluoroquinolone and a Group A drug.

**Interpretation of Table 2:**

Table 2 demonstrates the enormous magnitude of the DR-TB issue in Maharashtra, as evidenced by close to 8,000 cases reported during one year alone. The difficulty is rooted primarily in the huge share of MDR/RR-TB patients. The existence of the most resistant types of TB, namely—Pre-XDR and XDR-TB—amounting to more than 17% of DR-TB cases, poses a major concern. These are the hardest to treat and the treatment lasts longer, is more complicated, and is more expensive and sometimes even more toxic. The treatment success rate for MDR/RR-TB, although improving, is still below the national average and the WHO target of ≥85%, showing the presence of gaps in diagnosis, treatment adherence support, or management of adverse effects.



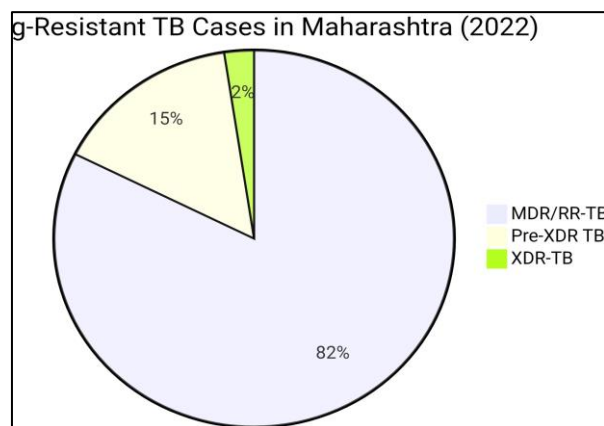**Figure 1: Composition of Drug-Resistant TB Cases in Maharashtra (2022)**

**Interpretation of Figure 1:** The pie chart gives a clear visual representation of the data from Table 2. It shows that while standard MDR/RR-TB is the major type of TB, about 20% of the DR-TB cases are made up of even more complicated resistance patterns. These patients, who are the most difficult to treat, often go through several treatment cycles and may still pass on resistant strains of the bacteria. The segment that needs to be treated the most difficult patients requires a rapid molecular diagnosis (like Whole Genome Sequencing), patient access to new medications such as Bedaquiline and Delamanid, and highly specialized care, which are the main components of the treatment.

### 3.5 Programmatic Performance: NTEP in Maharashtra

Maharashtra has a solid NTEP infrastructure in place. The key performance indica- tors are as follows:

- **Diagnostic Coverage:**
    The state has a dense network of designated microscopy centres and more than 150 molecular diagnostic machines (TrueNat/CBNAAT) distributed over the area. However, the tribal and remote areas are still facing accessibility problems.

- **Treatment Initiation:**
Nearly all (95%) the patients reported are given treatment, which is a clear indication of a strong linkage-to-care system.

- **Treatment Outcomes:**
    The treatment success rate for the new drug-sensitive TB patients of the 2021 cohort was 88%, which is almost at par with the national average of 88.5% but still short of the 90% target (India TB Report 2024). One of the main causes of treatment failure is loss-to-follow-up.

- **Private Sector Engagement:**
    The private healthcare sector is quite extensive in Maharashtra, particularly in Mumbai. The Mumbai Mission for TB Control is one of the initiatives that has contributed to the development of public-private mix (PPM) models, which not only increase notifications but also guarantee that private providers offer patients the same care as prescribed by the guidelines.

## 4   DISCUSSION
        The data shed light on a state's struggle with a troublesome and intricate TB epi- demic. The high TB prevalence in Maharashtra is due to the urban slums' very active transmission dynamics, the migrant populations' pointedly vulnerable status, and the diabetes-related amplifying effect of comorbidities. The state's financial success has not yet resulted in equal access to health care for all its citizens.

**Urbanization as a Double-Edged Sword:**
        Urbanization, on the one hand, is a source of economic opportunity, but on the other hand, it has resulted in" urban TB reservoirs" due to unplanned growth. The conditions in slums—overcrowding, poor ventilation, malnutrition, and limited access to clean water and sanitation—are similar to the classic social determinants of TB from the industrial revolution era. In order to prevent TB transmission in these areas, the 'passive case finding' approach will not work. The active case-finding campaigns through door-to-door screening and the use of mobile diagnostic vans in high-risk wards are essential but need to be sustained and scaled up.

**The Migrant Vulnerability:** The migrants, who are the mainstay of the construction and informal services in Maharashtra, are living under dire circumstances, are having very little legal rights to the services of the city, and are afraid of losing their wages if they go to doctors. They are usually late in getting diagnosed, are more prone to interrupting treatment because of their movements, and are hard to trace. Cross-sectional research in Pune showed that the workers in the construction industry who were migrants had a TB prevalence of several times higher than that of the general public, besides significant de- lays in diagnosis (Dhavan *et al.,* 2017). The NTEP's" patient-provider support agencies" and Nikshay Poshan Yojana (nutritional support scheme) are praiseworthy initiatives, but they must be backed by interstate coordination and workplace-based interventions.

**The Syndemic of TB and Diabetes:**
        The situation of diabetes being very prevalent among TB patients in Maharashtra, the case is really serious. This syndemic is characterized by the worst clinical outcomes, which include higher rates of drug resistance, treatment failure, relapse, and mortality. There is an immediate requirement for dual screening: all patients with TB must undergo screening for diabetes; and those with diabetes in areas with a high burden of TB should receive regular screening for symptoms of TB. Integrated management protocols must be established at primary healthcare.

**Confronting the DR-TB Crisis:**
        The very large scale of drug-resistant TB (DR-TB) crisis, including the most severe forms of it, points out the fact that resistant strains are still being transmitted and management of drug-sensitive TB is still not done effectively, which is the main cause of resistance development. The treatment success rate in Maharashtra, which has been a forerunner in drug replacement and in shortening regimens, still needs to be further improved. Totally the treatment needs many patient support activities: side-effects of the medications that need to be managed, mental health counseling and very strong social support to avoid poor treatment and high costs from which patients fall back. Therefore, infection control measures are to be implemented in hospitals and high-density community areas as these are the only means to put an end to the spread of resistant strains.

**Strengthening the NTEP: The Path Forward:**
**Maharashtra has a strong TB control program that still needs to be greater in some aspects of the program:**

**1. Precision Public Health:**
The specific data collection and analysis should be performed at the district and ward levels so that the necessary interventions can be directed. The areas that bear the highest burden of disease must be detected for intensive, localized action.

**2. Community Engagement:**
It is very important to involve local communities as partners in educating, tracing contacts and ensuring treatment adherence, especially in slum and tribal areas. The role of community health workers (ASHAs) has to be made stronger.

**3. Tackling Social Determinants:**
Working together of the different government departments (urban development, labor, food and civil supplies) is necessary in order to deal with overcrowding, malnutrition, and occupational health risks.

**4. Research and Innovation:**
Maharashtra, with its top medical and research institutions, should conduct operational research on care models for urban TB, migrant health, and managing TB-Diabetes comorbidity.

# 5 CONCLUSION

The epidemic of tuberculosis in Maharashtra is very complicated, and it is mainly connected with the state's economic and social issues. It is caused by the high density of cities, movement of people, and more and more serious illnesses coming together. Even though the state has been quite successful in notifying cases and has a strong programmatic framework under NTEP, still, the high burden that does not go down, urban concentration of cases and rise of drug-resistant TB powerhouse perceive that commendable current efforts are still inadequate for elimination.

The TB elimination target of 2025 is now a distant dream for Maharashtra, as well as for the rest of India. However, this should not be seen as a cause for disappointment but rather a challenge to throw in twice as much effort with a long-term and sustainability-oriented vision. One needs to shift the focus from a narrow, disease-specific target to the broader mission of building a health system and society that is TB-resistant. This entails taking bold actions to address the social determinants of health, ensuring the provision of truly universal health coverage that does not exclude any migrants or slum dwellers, and maintaining a continuous and vigorous effort aimed at preventing both the development and transmission of drug resistance.

The war on TB in Maharashtra is proof of India's dedication to health equity. It means going for medical solutions and we have to take on social, economic, and town planning measures—no kidding. The points picked up will not only be for India but also for every high-burden country that is aiming for TB-free future. The road is long, but if we have the continuous political will, the right amount of resources, community participation and a thorough plan that targets both the germ and the environment where it flourishes, then Maharashtra can actually turn from a high-burden state to a pioneer in the fight against TB.

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