### Overview of India's National Tuberculosis Elimination Programme (NTEP)

India's NTEP, launched under the National Strategic Plan (NSP) 2017-2025, aims to eliminate tuberculosis (TB) by 2025, five years ahead of the global Sustainable Development Goal (SDG) target of 2030. Elimination is defined as reducing TB incidence to less than 44 cases per 100,000 population, mortality to 3 deaths per 100,000, and ensuring zero catastrophic costs for affected households. The program operates on four pillars: Detect, Treat, Prevent, and Build (DTPB), emphasizing early diagnosis, quality treatment, prevention among high-risk groups, and multisectoral collaboration. Key initiatives include the Pradhan Mantri TB Mukt Bharat Abhiyaan (launched in 2022), which has engaged over 160,000 Ni-kshay Mitras to support 1.14 million patients with nutrition, and intensified case-finding campaigns like the 100-day TB Mukt Bharat Abhiyaan.

As of 2025, India has made notable progress: TB incidence declined by 17.7% from 2015 to 2023 (from 237 to 195 per 100,000), and mortality by 24% (from 28 to 22 per 100,000), outperforming the global averages of 8.3% and unspecified declines, respectively.<grok:render card\_id="6d0e09" card\_type="citation\_card" type="render\_inline\_citation">

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</grok:render> Notifications reached a record 26.07 lakh cases in 2024, reflecting improved detection through private sector engagement (up sevenfold since 2015, contributing 33% of notifications in 2023) and tools like molecular diagnostics.<grok:render card\_id="a50982" card\_type="citation\_card" type="render\_inline\_citation">

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</grok:render> However, India still accounts for 27% of global TB cases, with an estimated 2.82 million new cases and 331,000 deaths in 2022.<grok:render card\_id="bed488" card\_type="citation\_card" type="render\_inline\_citation">

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</grok:render> Drug-resistant TB (DR-TB) affects 2.5% of new cases and 13% of previously treated ones, while HIV co-infection is at 2%.<grok:render card\_id="259894" card\_type="citation\_card" type="render\_inline\_citation">

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</grok:render> Recent campaigns, such as the 100-day intensified drive, have accelerated case detection but highlight persistent gaps.<grok:render card\_id="cb2c0a" card\_type="citation\_card" type="render\_inline\_citation">

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</grok:render> Overall, experts agree the 2025 elimination target is unattainable, with slow declines failing to meet even WHO's 2025 milestones (50% incidence reduction and 75% mortality reduction from 2015 baselines).<grok:render card\_id="a7bdce" card\_type="citation\_card" type="render\_inline\_citation">

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### Analysis of Key Problems in the TB Elimination Programme

Despite advancements, the program faces multifaceted challenges rooted in epidemiological, systemic, socio-economic, and operational factors. These include:

- \*\*Epidemiological Challenges\*\*: High burden of multidrug-resistant (MDR) and extensively drug-resistant (XDR) TB, with India having the world's highest MDR-TB load. XDR-TB cases are estimated at 8,000 annually, with low treatment success rates (31% in older data).<grok:render card\_id="d3b3c2" card\_type="citation\_card" type="render\_inline\_citation">

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</grok:render> Co-infections (e.g., HIV-TB) and latent TB in vulnerable populations exacerbate transmission.

- \*\*Diagnostic and Surveillance Issues\*\*: Delayed diagnosis due to underreporting, especially in private sectors and remote areas. Only partial access to genetic tests like molecular diagnostics, leading to missed cases.<grok:render card\_id="bd6975" card\_type="citation\_card" type="render\_inline\_citation">

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</grok:render><grok:render card\_id="cd6787" card\_type="citation\_card" type="render\_inline\_citation">

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</grok:render> The COVID-19 pandemic caused delays, widening the gap between targets and achievements.<grok:render card\_id="b8da08" card\_type="citation\_card" type="render\_inline\_citation">

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- \*\*Treatment and Access Barriers\*\*: Drug shortages, even in urban areas, and bureaucratic hurdles for migrants denying treatment.<grok:render card\_id="899494" card\_type="citation\_card" type="render\_inline\_citation">

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</grok:render> Inadequate rollout of shorter regimens and new drugs like bedaquiline and delamanid, limited to select centers.<grok:render card\_id="adc045" card\_type="citation\_card" type="render\_inline\_citation">

<argument name="citation\_id">22</argument>

</grok:render> High dropout rates and low success rates persist.

- \*\*Socio-Economic and Behavioral Factors\*\*: Stigma, lack of awareness, and poor health-seeking behavior contribute to transmission.<grok:render card\_id="1765f9" card\_type="citation\_card" type="render\_inline\_citation">

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</grok:render> Catastrophic costs affect 7-32% of drug-sensitive TB patients and 68% of DR-TB cases, linked to poverty, malnutrition, and overcrowding.<grok:render card\_id="80d4fc" card\_type="citation\_card" type="render\_inline\_citation">

<argument name="citation\_id">25</argument>

</grok:render> Disparities are stark in remote regions like Jammu & Kashmir (408 TB deaths in recent data) and among socially vulnerable groups.<grok:render card\_id="0f168e" card\_type="citation\_card" type="render\_inline\_citation">

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- \*\*Systemic and Infrastructure Gaps\*\*: Staff vacancies in rural health facilities, insufficient budget, and variable healthcare access due to high population density and socio-economic disparities.<grok:render card\_id="c49908" card\_type="citation\_card" type="render\_inline\_citation">

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</grok:render><grok:render card\_id="b9f274" card\_type="citation\_card" type="render\_inline\_citation">

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</grok:render> Private sector integration, while improved, remains uneven.

- \*\*Regional and Emerging Issues\*\*: State-level disparities mask national progress, with higher burdens in deprived areas.<grok:render card\_id="871977" card\_type="citation\_card" type="render\_inline\_citation">

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</grok:render> Two TB deaths occur every three minutes, underscoring urgency.<grok:render card\_id="00aa55" card\_type="citation\_card" type="render\_inline\_citation">

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These problems are interconnected, with socio-economic drivers amplifying epidemiological ones, and systemic gaps hindering effective responses.

### Identification of Burning Problems

Based on current data and expert analyses, the most critical ("burning") problems as of September 2025 are those posing immediate threats to progress and requiring urgent intervention. Prioritizing from sources, they include:

1. \*\*Multidrug-Resistant TB (MDR/XDR-TB) Prevalence and Treatment Access\*\*: With high resistance rates and limited new drug availability, this risks reversing gains and replacing drug-susceptible TB with untreatable forms.<grok:render card\_id="661fa6" card\_type="citation\_card" type="render\_inline\_citation">

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2. \*\*Delayed Diagnosis and Underreporting in Vulnerable Populations\*\*: Persistent gaps in remote, migrant, and high-risk groups lead to ongoing transmission and missed opportunities for early intervention.<grok:render card\_id="838038" card\_type="citation\_card" type="render\_inline\_citation">

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3. \*\*Catastrophic Costs and Nutritional Deficits for Patients\*\*: Financial burdens and malnutrition reduce treatment adherence, worsening outcomes and perpetuating poverty cycles.<grok:render card\_id="9449bb" card\_type="citation\_card" type="render\_inline\_citation">

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4. \*\*Human Resource and Infrastructure Shortages\*\*: Staff vacancies and drug shortages, especially in rural areas, undermine program delivery.<grok:render card\_id="e9d1d3" card\_type="citation\_card" type="render\_inline\_citation">

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5. \*\*Stigma and Low Community Awareness\*\*: These drive poor health-seeking behavior and hinder community engagement efforts like Ni-kshay Mitra.<grok:render card\_id="9ce0e8" card\_type="citation\_card" type="render\_inline\_citation">

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### Devised Research Protocols to Address Burning Problems

To generate evidence-based solutions, the following research protocols are proposed. These are designed as feasible, ethical studies leveraging India's existing infrastructure (e.g., NTEP data, Ni-kshay portal) and could be funded via ICMR or WHO collaborations.

1. \*\*For MDR/XDR-TB Prevalence and Treatment Access\*\*:

- \*\*Study Design\*\*: Prospective cohort study with embedded randomized controlled trial (RCT).

- \*\*Objective\*\*: Evaluate the effectiveness of expanded access to shorter DR-TB regimens (e.g., 6-9 months with bedaquiline/delamanid) in reducing treatment failure and resistance emergence.

- \*\*Methods\*\*: Recruit 2,000 DR-TB patients from high-burden states (e.g., Maharashtra, Uttar Pradesh). Randomize half to standard vs. expanded access arms. Follow for 24 months, tracking outcomes via sputum culture, genotyping, and adherence metrics. Use survival analysis for time-to-cure.

- \*\*Sample Size and Duration\*\*: Powered for 80% detection of 20% improvement in success rates; 3-year study.

- \*\*Expected Outputs\*\*: Policy recommendations for nationwide rollout of new drugs, identifying resistance hotspots.

2. \*\*For Delayed Diagnosis and Underreporting in Vulnerable Populations\*\*:

- \*\*Study Design\*\*: Mixed-methods implementation research (quantitative surveys + qualitative focus groups).

- \*\*Objective\*\*: Assess barriers to diagnosis in migrants and remote communities and test mobile diagnostic interventions.

- \*\*Methods\*\*: Survey 5,000 individuals in 10 districts (urban slums, rural tribal areas). Use geospatial mapping to identify underreporting zones. Pilot mobile units with AI-enabled X-rays in intervention sites vs. controls. Analyze via logistic regression for factors like migration status.

- \*\*Sample Size and Duration\*\*: Stratified sampling; 2-year study with 6-month intervention phase.

- \*\*Expected Outputs\*\*: Guidelines for targeted active case-finding, integrating with NTEP's DTPB pillars.

3. \*\*For Catastrophic Costs and Nutritional Deficits\*\*:

- \*\*Study Design\*\*: Longitudinal economic evaluation with RCT component.

- \*\*Objective\*\*: Quantify costs and test enhanced nutritional support (e.g., expanded Ni-kshay Mitra kits) on adherence and outcomes.

- \*\*Methods\*\*: Enroll 1,500 TB patients, tracking household expenditures pre/post-diagnosis using WHO TB costing tools. Randomize to standard vs. augmented nutrition (e.g., high-protein supplements). Use cost-effectiveness analysis (ICER) and propensity score matching.

- \*\*Sample Size and Duration\*\*: Powered for cost reductions; 18-month follow-up.

- \*\*Expected Outputs\*\*: Evidence for scaling nutritional aid to achieve zero catastrophic costs.

4. \*\*For Human Resource and Infrastructure Shortages\*\*:

- \*\*Study Design\*\*: Cluster-randomized trial with health systems modeling.

- \*\*Objective\*\*: Evaluate task-shifting (e.g., training community health workers) to address vacancies and its impact on program delivery.

- \*\*Methods\*\*: Randomize 20 districts to intervention (task-shifting + telemedicine) vs. standard care. Measure metrics like case notification rates and drug stockouts via routine NTEP data. Apply system dynamics modeling (e.g., using Python/SymPy for simulations) to predict scaling effects.

- \*\*Sample Size and Duration\*\*: 10 clusters/arm; 2-year study.

- \*\*Expected Outputs\*\*: Blueprint for workforce optimization, informing budget allocations.

5. \*\*For Stigma and Low Community Awareness\*\*:

- \*\*Study Design\*\*: Qualitative action research with pre/post surveys.

- \*\*Objective\*\*: Develop and test community-led anti-stigma campaigns on health-seeking behavior.

- \*\*Methods\*\*: Conduct focus groups and in-depth interviews with 500 patients/community members in stigma-prone areas. Design interventions (e.g., media campaigns via local influencers). Evaluate via stigma scales (e.g., WHO TB Stigma Assessment) and interrupted time-series analysis of notification trends.

- \*\*Sample Size and Duration\*\*: Iterative cycles; 1-year study.

- \*\*Expected Outputs\*\*: Tailored awareness modules for integration into PMTBMBA.

These protocols emphasize multidisciplinary approaches, ethical considerations (e.g., informed consent, equity), and alignment with NTEP goals to accelerate evidence generation for post-2025 strategies.