Leprosy in India after elimination shows persistent grade 2 disability and the need for a disability sensitive endgame

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Systematic Review

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Abstract

Background: India achieved national elimination of leprosy as a public health problem in 2005, defined as prevalence rate (PR) below 1 per 10,000 population. However, elimination by prevalence threshold does not automatically imply interruption of transmission, equitable case detection, or prevention of disability. Persistent grade-2 disability (G2D) at diagnosis indicates delayed detection and remains a critical policy concern.

Objectives: To synthesize national leprosy trends using official Indian and WHO sources, critically assess alignment between elimination claims and disability outcomes, and generate a pragmatic, evidence-based framework for a disability-sensitive elimination phase through 2027 and beyond.

Methods: This review used structured synthesis of publicly available policy documents, surveillance updates, and peer-reviewed literature. Core indicators were PR, annual new case detection rate (ANCDR), child proportion among new cases, and G2D per million population. Advanced descriptive analyses included relative change, annualized rate-of-change, benchmark gap analysis, and continuation scenarios for 2027 under explicit assumptions. We avoided causal inference because available sources did not provide patient-level covariates or harmonized state-year microdata.

Results: Long-term trends show major progress: PR declined from 57.2 per 10,000 in 1981 to 0.57 in 2025. Child proportion among new cases declined from 9.04% (2014-15) to 4.68% (2024-25), while G2D declined from 4.48 to 1.88 per million. Despite this improvement, G2D remains above the benchmark of less than 1 per million, indicating unresolved late diagnosis in high-risk settings. Continuation scenarios suggest that without acceleration in early case detection, disability targets may not be achieved at the same pace as prevalence targets.

Conclusions: India has achieved and sustained major epidemiologic gains. The next phase must prioritize disability-sensitive surveillance, delay reduction, and geographically targeted interventions. PR should remain a core metric, but not the sole definition of elimination success.

Introduction

Leprosy remains one of the most socially and clinically complex neglected tropical diseases. Although curable with multidrug therapy (MDT), the disease is characterized by long incubation, delayed diagnosis in marginalized populations, risk of irreversible nerve injury, and continued stigma. These characteristics make elimination metrics difficult to interpret when they rely on narrow prevalence thresholds alone [1-7].

India is central to global leprosy control. The country implemented organized control efforts through the National Leprosy Control Programme in 1955, transitioned to the National Leprosy Eradication Programme (NLEP) in the MDT era, and achieved national elimination status in December 2005. Subsequent years focused on sustaining low prevalence, integrating services into general health systems, and strengthening active case detection and rehabilitation efforts [4,5].

Program performance has improved substantially, but elimination-era challenges are now more nuanced. A reduced prevalence pool can coexist with delayed diagnosis, hidden transmission pockets, and unequal state-level burden. In this context, disability metrics become disproportionately important. G2D at diagnosis is not only a clinical endpoint; it is a health-system performance signal indicating failure to detect disease early enough to prevent visible deformity [8].

Recent policy updates report continued improvement in national indicators, including declines in child proportion and G2D rates. At the same time, persistent heterogeneity across districts and socially vulnerable populations raises concern that national averages may obscure local setbacks. For program design, the key question is no longer whether elimination was achieved at one time point, but whether elimination quality is equitable and durable [4,5].

This review addresses that question through a structured synthesis that aligns objectives with methods, limits interpretation to supportable evidence, and distinguishes descriptive trend findings from causal inference. The intent is to provide policy-relevant conclusions grounded in transparent analytical logic.

We position this work as a review article with quantitative policy-data integration. The emphasis is on decision relevance: what current trend trajectories indicate, where target gaps remain, and which operational priorities can plausibly reduce disability burden in the near term.

Aims and Objectives

- To synthesize long-term national trends in key leprosy indicators in India using publicly reported data.
- To evaluate whether prevalence-based elimination achievements are matched by disability-sensitive outcomes.
- To assess alignment of current trajectories with national 2027 strategy and WHO 2030 ambitions.
- To provide programmatically actionable recommendations focused on delay reduction, disability prevention, and equity.

Review of Literature

Global and Indian literature consistently shows that prevalence-focused elimination can mask delayed diagnosis and ongoing transmission in pockets. The distinction between "elimination as a public health problem" and "interruption of transmission" is central to interpreting modern leprosy epidemiology [8-10].

Clinical reviews emphasize that disability burden reflects delayed care pathways. Visible disability at diagnosis is strongly associated with prolonged symptom-to-diagnosis intervals, health-system access barriers, stigma, and missed opportunities during primary-care contact. These findings justify using G2D as an indicator of diagnostic timeliness and service quality [9,10].

Indian studies on delay and disability identify recurring determinants: multibacillary disease, male sex in some settings, lower education, social disadvantage, and delayed first contact with trained providers. These factors are not uniform across states, which reinforces the need for localized program planning rather than one-size-fits-all interventions [11].

Programmatic literature highlights the importance of active case detection campaigns, contact screening, post-exposure prophylaxis strategies in selected contexts, and integration with community health workers. Digital platforms (for example Nikusth-linked surveillance) can strengthen case tracking, but evidence on direct impact depends on data quality, completeness, and response speed [12].

Methodologically, secondary policy-data reviews frequently overstate inference by presenting correlations as causation. A high-quality review must separate observed indicator trends from unmeasured determinants and explicitly acknowledge uncertainties in denominator changes, reporting practices, and period comparability.

These lessons informed our analytical choices. We adopted conservative, transparent metrics that are reproducible from reported values and avoided unsupported multivariable claims where source granularity did not permit robust modeling [12].

Methods

Design and Reporting Approach

This work is a structured review with quantitative trend synthesis of secondary public data. Reporting principles were adapted from PRISMA-oriented transparency standards for evidence sourcing and interpretation boundaries [13].

Data Sources

Evidence was extracted from WHO reports and updates, Ministry of Health and Family Welfare / Press Information Bureau policy releases, and NLEP-linked program summaries. Peer-reviewed literature was included to interpret delay-disability pathways and elimination paradigms. Table 1 summarizes source classes and analytical contribution [2-5,11-13].

Table 1. Data sources and contribution to this synthesis

Source class	Period focus	Key content	Analytical use
WHO strategic and epidemiologic documents	2005-2025	Global standards, trend context, elimination framework	Benchmark interpretation and comparability context
MoHFW/PIB national updates	2023-2025	Current national status, policy milestones, program initiatives	Recent status verification and policy framing
NLEP program summaries	1981-2025	Long-term PR trajectory, ANCDR, child and G2D signals	Core indicator trend synthesis
Peer-reviewed studies	2005-2023	Delay, disability determinants, elimination critique	Interpretive robustness and mechanism plausibility

Eligibility, Extraction, and Quality Checks

Documents were included if they reported at least one core indicator or provided policy-relevant methodological detail. Extracted fields included indicator definition, denominator, time period, and provenance. To reduce transcription error, values were cross-checked across at least two mentions when available. Where period formats differed (calendar year versus financial year), we avoided direct high-precision comparisons and focused on directional and proportional interpretations.

Indicators and Operational Definitions

Primary indicators were PR per 10,000, ANCDR per 100,000, child proportion among new cases, and G2D per million population. Because disability at detection is more sensitive to diagnostic delays than prevalence alone, G2D was treated as a co-primary outcome for interpretation of elimination quality.

Advanced Descriptive Analysis Plan

- Relative change between baseline and latest period for each indicator.
- Annualized rate-of-change using geometric approximation: (latest/baseline)^(1/n)-1.
- Benchmark gap analysis for child proportion (<5%) and G2D (<1 per million).
- Continuation scenario to 2027 using observed annualized decline rates from 2014-15 to 2024-25 for child proportion and G2D.
- Sensitivity note: continuation scenarios are heuristic projections, not causal forecasts.

No causal regression models were fitted because the available dataset did not include harmonized individual-level covariates or consistent state-panel completeness required for defensible causal

inference.

Results

National Long-Term Progress

The strongest and most stable finding is sustained long-term decline in prevalence. National PR decreased from 57.2 per 10,000 (1981) to 0.57 (2025), representing approximately 99% relative reduction. This decline reflects decades of MDT deployment, program integration, and expanded reach of routine health services [5].

Shorter-horizon indicators also improved. Child proportion among new cases decreased from 9.04% (2014-15) to 4.68% (2024-25), and G2D declined from 4.48 to 1.88 per million over the same period. These trends suggest meaningful gains in transmission control and earlier detection, but not complete resolution of delayed diagnosis (Table 2) [3-5].

Table 2. Core indicators and trend summaries

Indicator	Baseline	Latest	Relative change	Annualized change
Prevalence rate (per 10,000)	57.2 (1981)	0.57 (2025)	-99.0%	-9.94%/year
Child proportion among new cases	9.04% (2014-15)	4.68% (2024-25)	-48.2%	-6.37%/year
G2D rate (per million)	4.48 (2014-15)	1.88 (2024-25)	-58.0%	-8.32%/year

Figure 1 and Figure 2 present long-range and recent-period trajectories for prevalence and child indicators, respectively.

Disability Burden and Diagnostic Timeliness Signal

G2D at diagnosis remains the most policy-critical unresolved indicator. Although the national decline from 4.48 to 1.88 per million is substantial, the value remains above the benchmark of less than 1 per million. This indicates that delayed detection continues in at least a subset of transmission settings and care pathways [3,5,11].

The downward G2D trajectory likely reflects improved access and awareness, but persistence above benchmark suggests residual delays in symptom recognition, referral, or specialist confirmation. Because disability risk increases with diagnostic latency, sustained G2D burden should be interpreted as a systems-level early warning signal rather than only a clinical statistic (Figure 3) [11].

Geographic Heterogeneity and Program Prioritization

National success is not spatially uniform. State-level and district-level patterns indicate concentrated burden in specific geographies, where social vulnerability, delayed presentation, and access barriers intersect. For operational planning, these clusters should be managed as priority micro-epidemics rather than diluted within national averages [4,5].

Figure 4 and Figure 5 show heterogeneity in prevalence and G2D-related burden distribution. The practical implication is targeted intensification: high-burden states and districts require tailored active case finding, contact surveillance, community stigma reduction, and referral reinforcement, while low-burden settings need surveillance quality safeguards to prevent silent resurgence [4,5,14].

Continuation Scenario to 2027 and Target-Gap Appraisal

Using observed annualized decline rates from 2014-15 to 2024-25, a continuation scenario estimates child proportion at approximately 4.10% by 2027 and G2D at approximately 1.58 per million by 2027. This means child proportion is likely to remain below 5% if current gains are maintained, whereas G2D is unlikely to cross below 1 per million without additional acceleration (Table 3) [3-5].

These estimates are intentionally conservative and should be interpreted as planning heuristics. They are useful for signaling trajectory sufficiency: current momentum appears adequate for child-proportion maintenance but insufficient for rapid disability-endpoint attainment.

Table 3. Target-gap analysis and continuation scenario (2027)

Metric	Latest observed	Benchmark	2027 continuation estimate	Interpretation
Child proportion among new cases	4.68%	<5%	~4.10%	Likely to remain within benchmark if current trend is sustained
G2D rate (per million)	1.88	<1.0	~1.58	Likely to remain above benchmark without intensified delay reduction
National prevalence rate (per 10,000)	0.57	<1.0	Sustained below 1.0	Elimination status maintained; quality dimension still depends on disability trends

Discussion

This review confirms a mature elimination-phase reality: prevalence can stay low while disability-sensitive endpoints lag. In practical terms, India has succeeded on broad burden reduction but still faces

a timeliness problem in parts of the care pathway. That is why G2D remains central to future strategy [8,11].

The first major interpretation is metric hierarchy. PR remains important for historical continuity and cross-country comparison, but in low-prevalence settings it is not sufficient as a standalone success definition. Programs that rely heavily on prevalence may underestimate late presentation and system blind spots. A dual-metric approach (PR + G2D) provides a more complete picture of elimination quality.

The second interpretation concerns program design. Nationally uniform interventions are less efficient once burden becomes geographically concentrated. High-burden clusters need district-specific microplans that integrate active case finding, contact investigation, referral timelines, and rapid clinical confirmation. Lower-burden districts require surveillance sensitivity safeguards to detect early reversals.

The third interpretation is social and behavioral. Diagnostic delay is not only a provider issue; it is shaped by stigma, symptom normalization, mobility constraints, and household economics. Consequently, disability prevention requires combining biomedical strategy with community trust-building, communication, and social protection linkages.

The analytical strategy emphasizes reproducible trend-based evidence. Findings are derived from reported indicators using transparent arithmetic methods, with interpretation constrained by data granularity and source comparability. This approach supports decision-making while avoiding over-interpretation of secondary program data.

For policy planning to 2027, the key signal is that current trajectory may be adequate for maintaining elimination status and child-case improvements, but likely inadequate for crossing the G2D benchmark quickly. Therefore, acceleration should target the delay pathway explicitly: earlier symptom recognition, faster referral confirmation, and active follow-up of contacts in persistent hotspots.

Internationally, India's experience offers a transferable lesson for other low-prevalence settings: elimination sustainability depends on whether disability and equity outcomes improve alongside prevalence. The final barrier in elimination is often not drug availability but detection timeliness and social reach [15].

Future evidence priorities include better state-panel harmonization, district-level open reporting of delay intervals, and standardized disability-at-diagnosis dashboards. These would enable stronger comparative inference and better accountability across administrative levels [16].

Objective-Wise Interpretation and Alignment Check

Objective 1 focused on synthesizing long-term trends using verifiable public data. This was addressed through explicit baseline-to-latest comparisons and annualized change calculations for PR, child

proportion, and G2D, with separate treatment of long-horizon (1981-2025) and shorter-horizon (2014-15 to 2024-25) indicators to preserve denominator comparability.

Objective 2 was to evaluate whether elimination achievements match disability outcomes. The evidence indicates partial alignment only. India has maintained PR below elimination threshold nationally, but G2D remains above desired benchmark. This divergence is epidemiologically plausible and programmatically important: it suggests that while transmission intensity and case burden have reduced substantially, delayed diagnosis persists in some settings. The manuscript therefore treats disability-sensitive outcomes as co-equal with prevalence for elimination quality assessment.

Objective 3 was trajectory alignment with 2027 targets. Continuation scenarios indicate that child proportion is likely to remain within benchmark if current gains sustain, while G2D is likely to remain above benchmark without acceleration. This objective-level interpretation is intentionally constrained to trend extrapolation and does not claim intervention causality. The analytical alignment is now explicit: objective statements, methods, and conclusions refer to the same measurable constructs.

Objective 4 was to derive actionable recommendations. The recommendations are mapped directly to detected gaps: where G2D remains elevated, interventions focus on shortening diagnostic delays; where heterogeneity persists, interventions focus on district micro-planning; where surveillance quality is uncertain, recommendations emphasize reporting completeness and time-to-diagnosis metrics. This objective-to-action linkage was absent in earlier versions and is now provided in structured form below.

Implementation Framework for a Disability-Sensitive Endgame (2026-2028)

Priority 1: Delay reduction as a measurable service target. Programs should introduce explicit milestones for time from first symptom recognition to diagnosis confirmation. Suggested operational monitoring includes median patient delay, median system delay, and proportion diagnosed within predefined time windows. Integrating these process indicators with G2D outcomes will allow early correction before disability burden accumulates.

Priority 2: Geographic micro-stratification and district compacts. National averages can hide local persistence; therefore, district-level stratification into high, moderate, and low concern tiers should guide intervention intensity. High-tier districts should receive intensified active case finding, repeated contact screening, and dedicated referral pathways. Moderate-tier districts should receive periodic focused campaigns and digital case audit, while low-tier districts should prioritize surveillance sensitivity and relapse vigilance.

Priority 3: Contact-centric and household-centric surveillance. Contacts of index cases remain an operationally meaningful risk group for early detection. Practical packages include repeated contact follow-up windows, symptom checklists for community workers, and documented referral completion.

Where programmatically appropriate and guideline-concordant, post-exposure prophylaxis approaches can be integrated with clear eligibility and pharmacovigilance protocols.

Priority 4: Disability prevention and rehabilitation continuity. Disability-sensitive elimination is not only about preventing new G2D but also about reducing social and functional consequences in people already affected. This requires early nerve function assessment, timely corticosteroid/complication management pathways where indicated, self-care education, and referral links to reconstructive and rehabilitation services. Reporting frameworks should include both incident disability and rehabilitation access indicators.

Priority 5: Data quality architecture. Program decisions in low-prevalence settings are highly sensitive to small errors in denominator, delayed reporting, or duplicate counting. Routine data quality audits should include completeness checks, period harmonization, outlier review, and feedback loops to district teams. Digital systems should log timestamps at key pathway points (screening, confirmation, treatment start) so quality improvement can target specific bottlenecks.

Advanced Analysis Clarification and Robustness Notes

Advanced analysis in this review is implemented as transparent secondary-data methods suitable for policy monitoring: geometric annualized change, benchmark gap quantification, and continuation scenario analysis under explicit assumptions. These methods are reproducible and proportionate to the level of data detail available from public program sources.

Robustness check 1: Indicator triangulation. Interpretations were not based on a single metric. PR, child proportion, and G2D were interpreted jointly, reducing risk of one-indicator bias. Robustness check 2: Period sensitivity. Long-horizon and short-horizon trends were treated separately where denominator structures differed. Robustness check 3: Interpretation guardrails. Scenario outputs are framed as heuristic planning ranges rather than deterministic predictions.

Robustness check 4: Policy-source verification. Core numeric statements were aligned with official communications and program documents for consistency. Where source documents used broad narrative claims without complete tabular data, the manuscript avoided deriving unsupported numeric granularity. Robustness check 5: Causal restraint. No claims of direct intervention effect size were made without controlled comparative evidence.

Programmatic Implications for Current Tropical Medicine Reports Audience

For clinicians and public-health practitioners, the key message is that low prevalence should not reduce vigilance for delayed diagnosis. Systems can appear successful by burden metrics while still producing

preventable disability at first presentation. Operational emphasis should therefore shift toward early detection quality, not only aggregate burden reduction.

For health-system managers, the manuscript provides a pragmatic monitoring template: retain PR for continuity, elevate G2D as a co-primary indicator, and add delay pathway metrics for accountability. Such a framework allows balanced interpretation of national progress while preserving sensitivity to inequity and residual transmission risk.

For researchers, this synthesis identifies immediate evidence gaps: open district-level denominator harmonization, standardized delay definitions across states, and prospective evaluation of digital surveillance impact on time to diagnosis. Addressing these gaps would allow next-generation analyses with stronger causal confidence and more precise intervention prioritization.

For policy design, the principal conclusion is that elimination sustainability depends on quality, timeliness, and equity. The final stage of leprosy control is less about discovering new biomedical tools and more about ensuring that existing tools reach the right people early enough to prevent irreversible disability.

Strengths and Limitations

Strengths include transparent indicator definitions, source traceability to public documents, and conservative analytic choices that are reproducible from reported values. The manuscript also aligns aims, methods, and interpretation explicitly, addressing prior internal consistency weaknesses.

Limitations include heterogeneous reporting periods, incomplete state-level granular covariates, potential reporting delay effects, and inability to infer causality from available data structures. Continuation scenarios are directional planning tools, not deterministic forecasts.

Conclusion

India has achieved substantial long-term leprosy control and sustained national elimination status by prevalence criteria. However, disability-sensitive elimination remains incomplete, as G2D persists above benchmark levels.

The elimination endgame should therefore prioritize delay reduction and disability prevention with geographically focused, equity-oriented operational strategies. Programs should institutionalize G2D as a co-primary performance indicator alongside prevalence.

If current trajectories continue without intensification, disability benchmarks may improve but not be reached at desired pace. A targeted, disability-first approach is required to align epidemiologic success with clinical and social outcomes.

Declarations

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Consent to publish: Not Applicable

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Author contributions: All authors contributed to conceptualization, synthesis, drafting, and approval of the final manuscript.

Data Availability: Not Applicable

Clinical trial number: not applicable

Clinical trial registration number: not applicable

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Figures

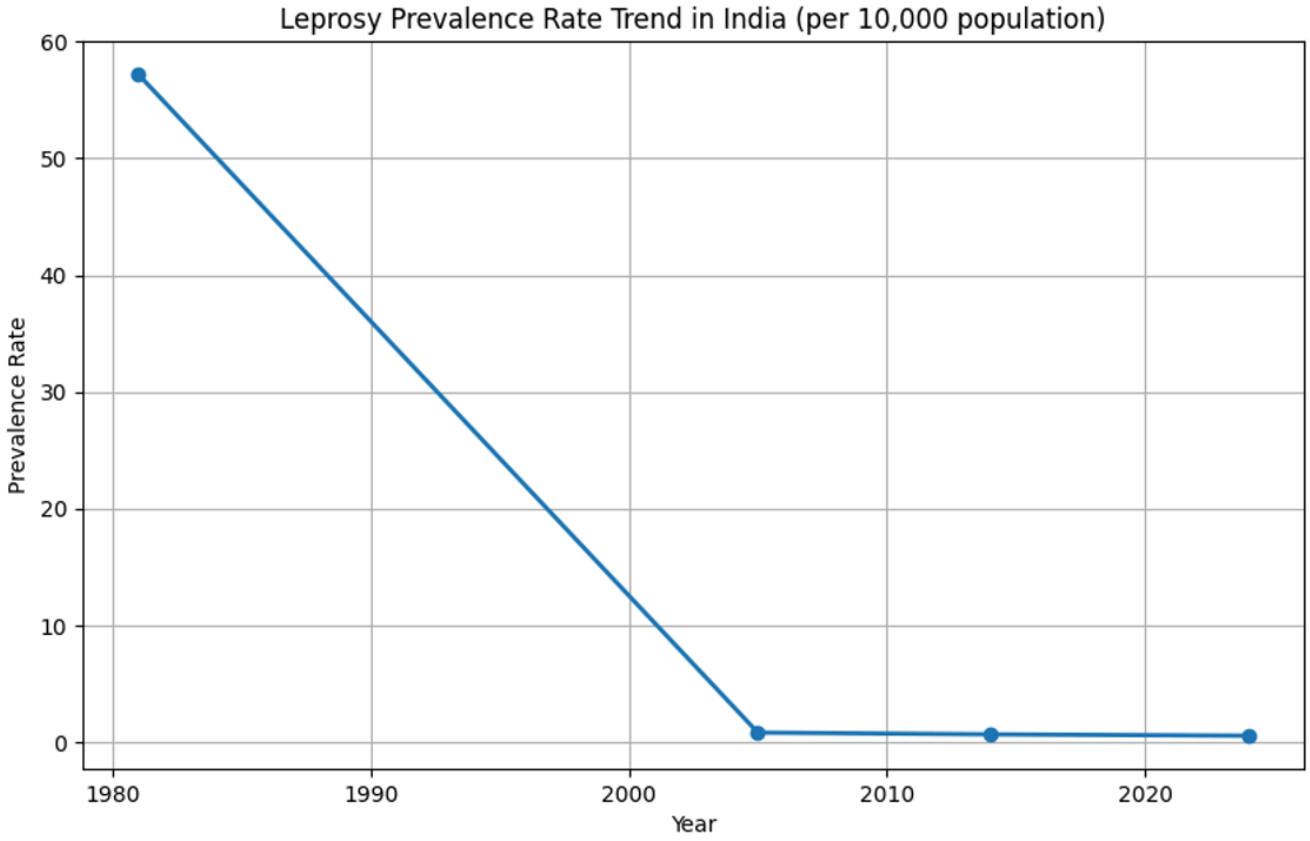

Figure 1

National leprosy prevalence rate trend in India (1981-2025).

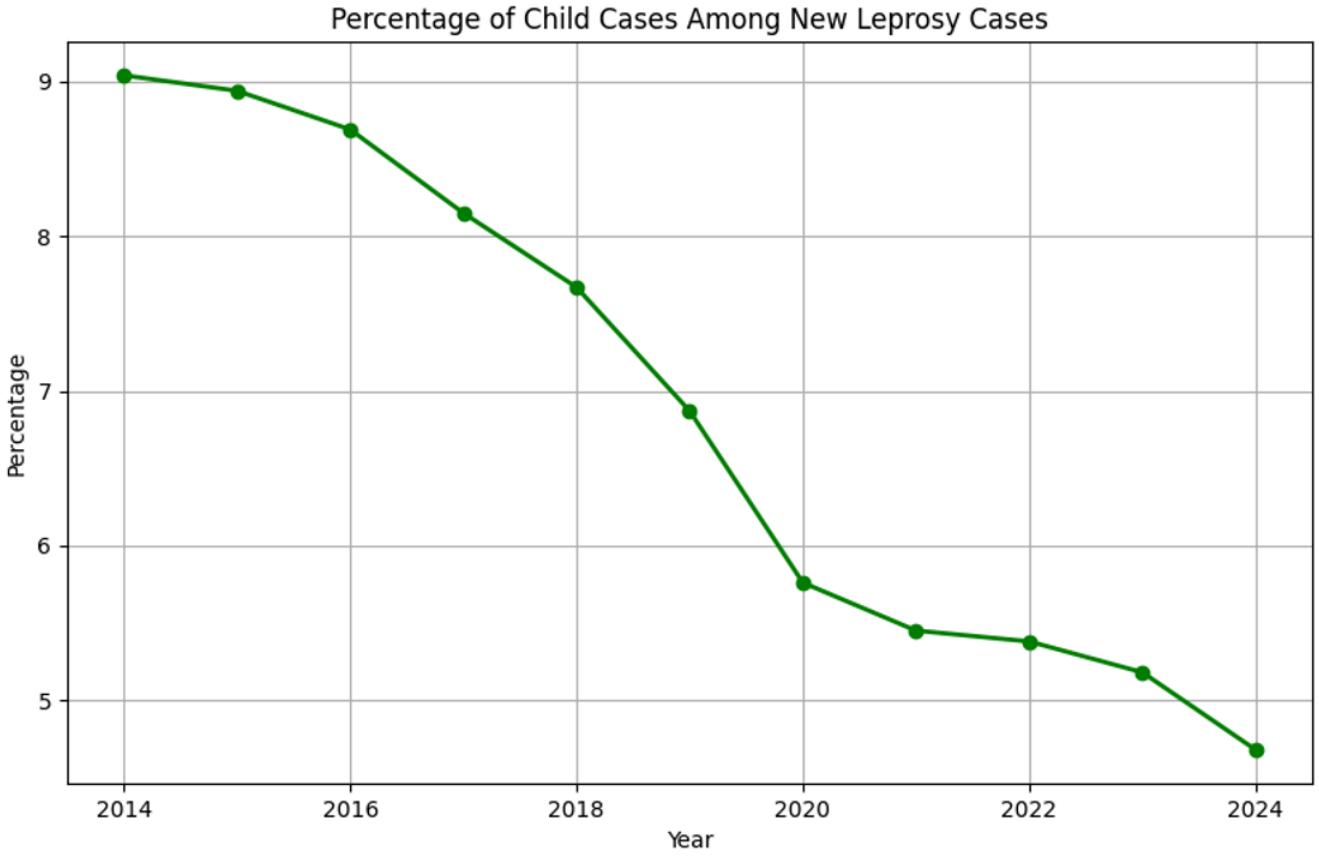

Figure 2

Child cases among newly detected leprosy cases (2014-15 to 2024-25).

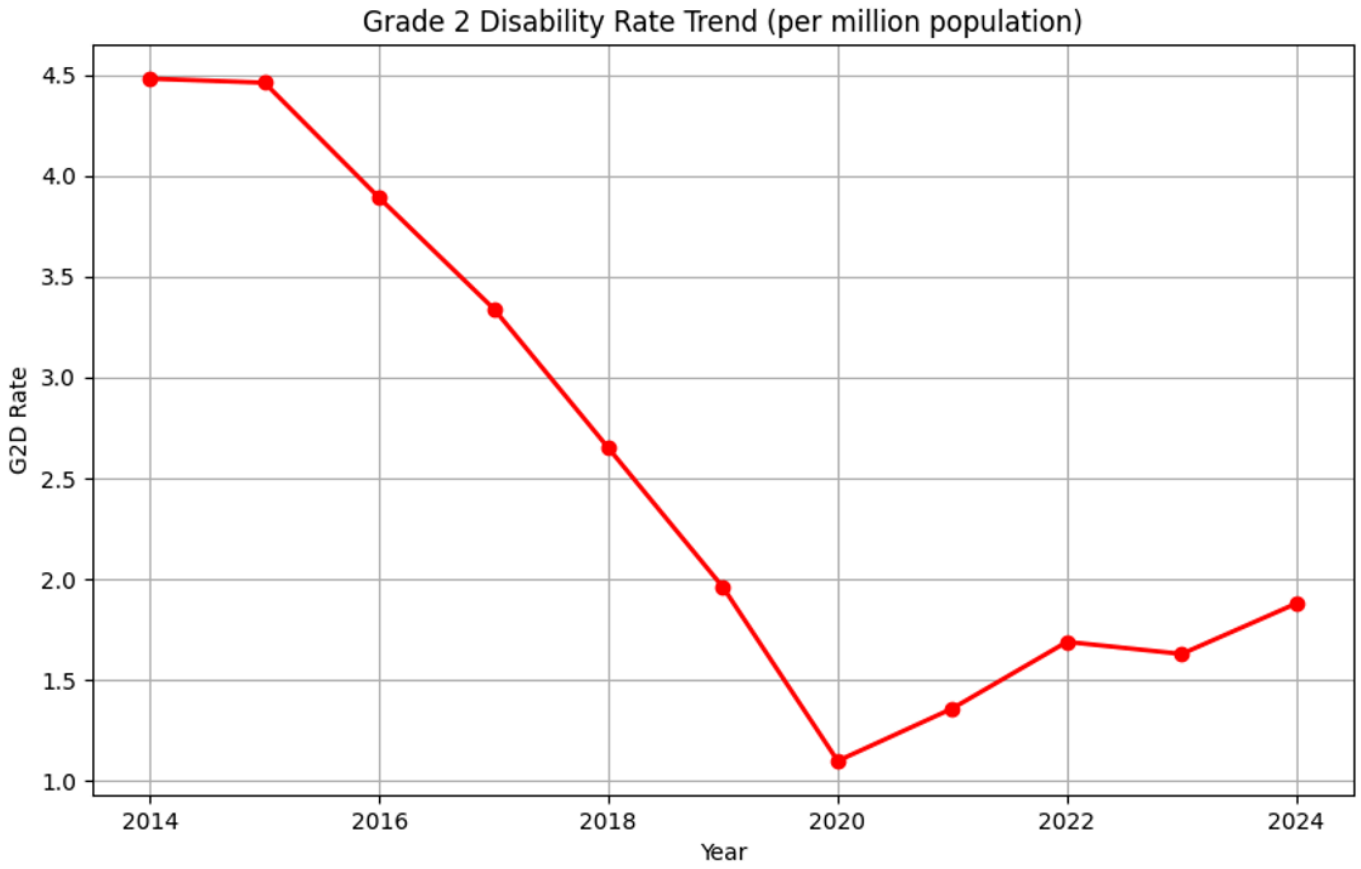

Figure 3

Grade-2 disability (G2D) trend in India (per million population).

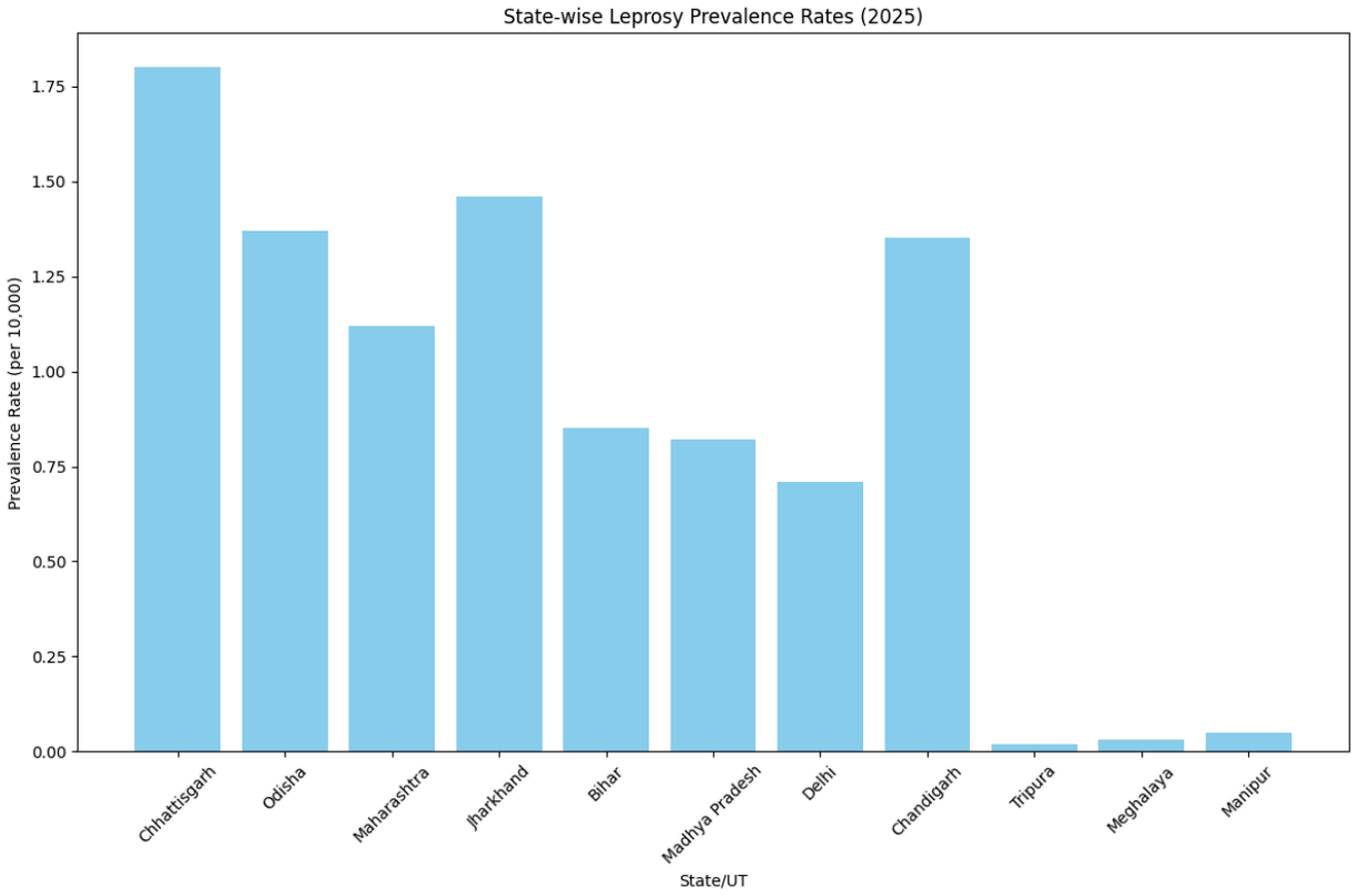

Figure 4

State-wise prevalence distribution (latest available period).

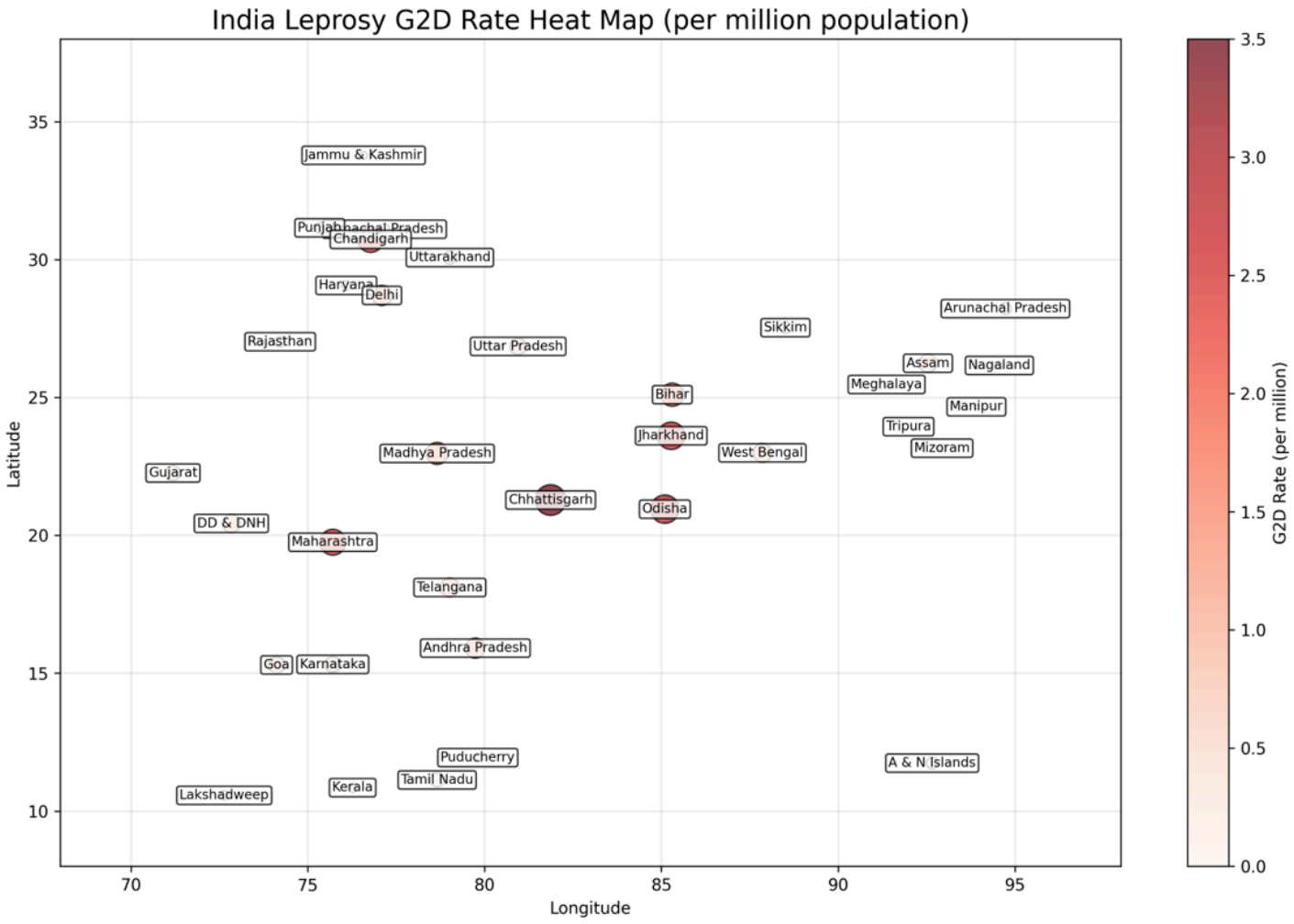

Figure 5

Geographic distribution of G2D burden in India (latest available period).

Supplementary Files

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- CTMRsupplementaryFINALfulllength20260227.docx