ORIGINAL ARTICLE

Burden Trends and Future Projections of Acute Glomerulonephritis in India till 2040: An Analysis from the Global Burden of Disease Study

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Abstract

Background: Glomerulonephritis (GN) remains a significant cause of kidney-related morbidity and mortality in low- and middle-income countries (LMICs). Despite advances in acute renal care in India, the national epidemiological trajectory and future burden of GN have not been comprehensively characterized.

Materials and methods: This study utilized Global Burden of Disease (GBD) 2023 data to estimate incidence, mortality, disability-adjusted life years (DALYs), years of life lost (YLLs), and years lived with disability (YLDs) due to GN in India from 1990 to 2023. Age-standardized rates (ASRs) were calculated per 100,000 population. Temporal trends were assessed using estimated annual percentage change (EAPC) from log-linear regression models. Future projections to 2040 were modeled using historical EAPC and population forecasts from the Institute for Health Metrics and Evaluation.

Results: From 1990 to 2023, India achieved a 75% reduction in age-standardized death rates (0.091–0.023 per 100,000; EAPC −4.42%, $p < 0.001$), while incidence remained stable (3.09 per 100,000; EAPC −0.05%, $p = 0.123$). DALYs declined 77% (2.49–0.58 per 100,000), driven by YLLs rather than disability (YLDs). Males experienced a 1.5-fold higher burden across all metrics. Marked geographic disparities emerged, with eastern states (Jharkhand, Chhattisgarh, Bihar) demonstrating 2–4-fold higher mortality than the national average despite similar incidence. By 2040, age-standardized death rates are projected to decline 52% further, but absolute incident cases will increase 18% (41,200–48,720) due to population growth.

Conclusion: India has achieved major reductions in GN mortality, yet stable incidence and persistent disability indicate that primary prevention and early detection remain inadequate. Without policy intervention, rising case numbers will place increasing demand on renal services. GN should be prioritized within national and subnational kidney health strategies as a sentinel indicator of health system preparedness in LMICs.

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Introduction

Acute glomerulonephritis (GN) is a leading cause of chronic kidney disease (CKD) and end-stage kidney failure worldwide, disproportionately affecting populations in low- and middle-income countries (LMICs), where access to early diagnosis and treatment remains limited.[1,2] Despite a global decline in mortality from communicable diseases, the burden of GN has persisted or transitioned toward chronic disability in several emerging economies, reflecting the unfinished agenda of renal health in the context of epidemiological and demographic transition.[3,4] India, home to nearly one-fifth of the world's population, represents a critical setting for understanding this transition, yet national estimates of GN burden that integrate incidence, mortality, disability-adjusted life years (DALYs), and projections of future trends have been limited.[5,6] Furthermore, existing GN studies in India have focused largely on biopsy cohorts or regional registries, which do not capture the full spectrum of disease across age groups, sexes, or the national population.[7,8]

This study is the first to use Global Burden of Disease (GBD) 2023 estimates and population-based forecasting models to provide a comprehensive, age- and sex-stratified assessment of historical temporal trends in burden of GN and to project the future burden to 2040. By combining historical trends with population projections, we provide novel insights into the evolving dynamics of GN in an LMIC context, where health systems are simultaneously tackling infectious diseases and rapidly escalating noncommunicable disease burden.[9] This approach not only quantifies the current renal health gap but also anticipates future service demands, informing national strategies for universal health coverage and Sustainable Development Goal (SDG) targets.

From a policy perspective, GN serves as a sentinel condition reflecting broader systemic issues, including environmental exposures, health care access inequities, and inadequate preventive care, which can be addressed through integrated kidney health strategies.[10,11] In contrast to prior research limited to static prevalence estimates, our analysis evaluates disease trajectory and models future burden under a "business-as-usual" scenario, offering actionable projections for policymakers. This uniquely positions GN as a critical tracer for renal health system readiness in India and other LMICs, with implications extending beyond nephrology to national health financing, workforce planning, and chronic disease prevention frameworks.

Materials and Methods

Ethics and Study Design

The study uses aggregated, de-identified, publicly available data, ethics approval was not required. We adhered to the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER). This study is a retrospective, population-based epidemiological analysis using publicly available data from the Global Burden of Disease Study 2023 (GBD 2023), coordinated by the Institute for Health Metrics and Evaluation (IHME).

Data Source

Data were extracted from the GBD Results Tool (https://ghdx.healthdata.org), which

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compiles standardized estimates using: (1) vital registration systems (limited coverage), (2) Sample Registration System (SRS), (3) verbal autopsy studies, (4) hospital administrative data, (5) published literature, and (6) regional covariates including Healthcare Access and Quality Index, Sociodemographic Index, and sanitation indicators. The analysis focused on India and examined the burden of acute glomerulonephritis (cause ID: 588) from 1990 to 2023. Acute glomerulonephritis was defined according to GBD 2023 case definitions, incorporating ICD-9 and ICD-10 codes (including N00-N01). GBD uses DisMod-MR 2.1, a Bayesian meta-regression tool, to ensure internal consistency across incidence, prevalence, remission, and mortality. For future projection, the data of population specific to India modeled till 2040 was derived from IHME

Data Collection

We extracted the following metrics: Incidence (number and age-standardized rate per 100,000 population); deaths; disability-adjusted life years (DALYs), the sum of years of life lost (YLLs) due to premature mortality and years lived with disability (YLDs) due to morbidity. Estimates were reported with 95% uncertainty intervals (UIs) derived from 1,000 posterior draws. All rates were age-standardized using the GBD world standard population. Data for the overall sex, as well as for male and female, were extracted. The data were collected from 1990 to 2023. For cross-sectional interpretation of age (2023), the age groups distribution selected was: <5 years, 5–14 years, 15–49 years, 50–69 years, and ≥70 years. The primary dataset (downloaded from October 25 to October 27, 2025) used in the study is openly available online for reproducibility and research: https://doi.org/10.5281/zenodo.17452285

Statistical Procedures

Age Group Contribution Analysis

For the year 2023, we calculated the proportional contribution of each age group to the national burden by dividing the absolute number of cases, deaths, DALYs, YLLs, or YLDs in each age category by the total national value for that metric. Results were expressed as percentages and visualized using stacked bar charts.

Trend and Sex Analysis

We estimated future trends in the incidence, mortality, disability-adjusted life years (DALYs), years of life lost (YLLs), and years lived with disability (YLDs) from acute glomerulonephritis in India from 2023 to 2040 using a log-linear trend projection model consistent with Global Burden of Disease (GBD) methodology. Age-standardized rates (ASRs) for both sexes combined were extracted from the GBD 2023 database for the period 1990–2023. The estimated annual percentage change (EAPC) for each metric was derived using a linear regression of the natural logarithm of the ASR against calendar year: . EAPC was calculated as: . The 95% uncertainty interval (UI) was computed from the standard error of β, using and . We also calculated EAPC for both sex also to estimate any statistical difference. The p-value for trend was derived from the *t*-test of the β coefficient, and a *p*-value < 0.05 was considered statistically significant, indicating a nonzero annual percentage change over time.

Future Trend Estimation

Future projections of ASR from 2024 to 2040 were generated by applying: . Baseline ASR uncertainty bounds in 2023 and the β uncertainty distribution were both propagated forward to obtain upper and lower uncertainty intervals. Projected absolute number of incident cases, deaths, DALYs, YLLs, and YLDs were calculated by multiplying the projected ASR by the projected Indian population for each year (2024–2040), obtained from the IHME Global Population Forecasts database (baseline/reference scenario). Absolute projections incorporated population uncertainty using the same propagation approach: . All projections assume no major policy or epidemiologic shift and represent a reference ("business-as-usual") scenario.

Statistical Analysis

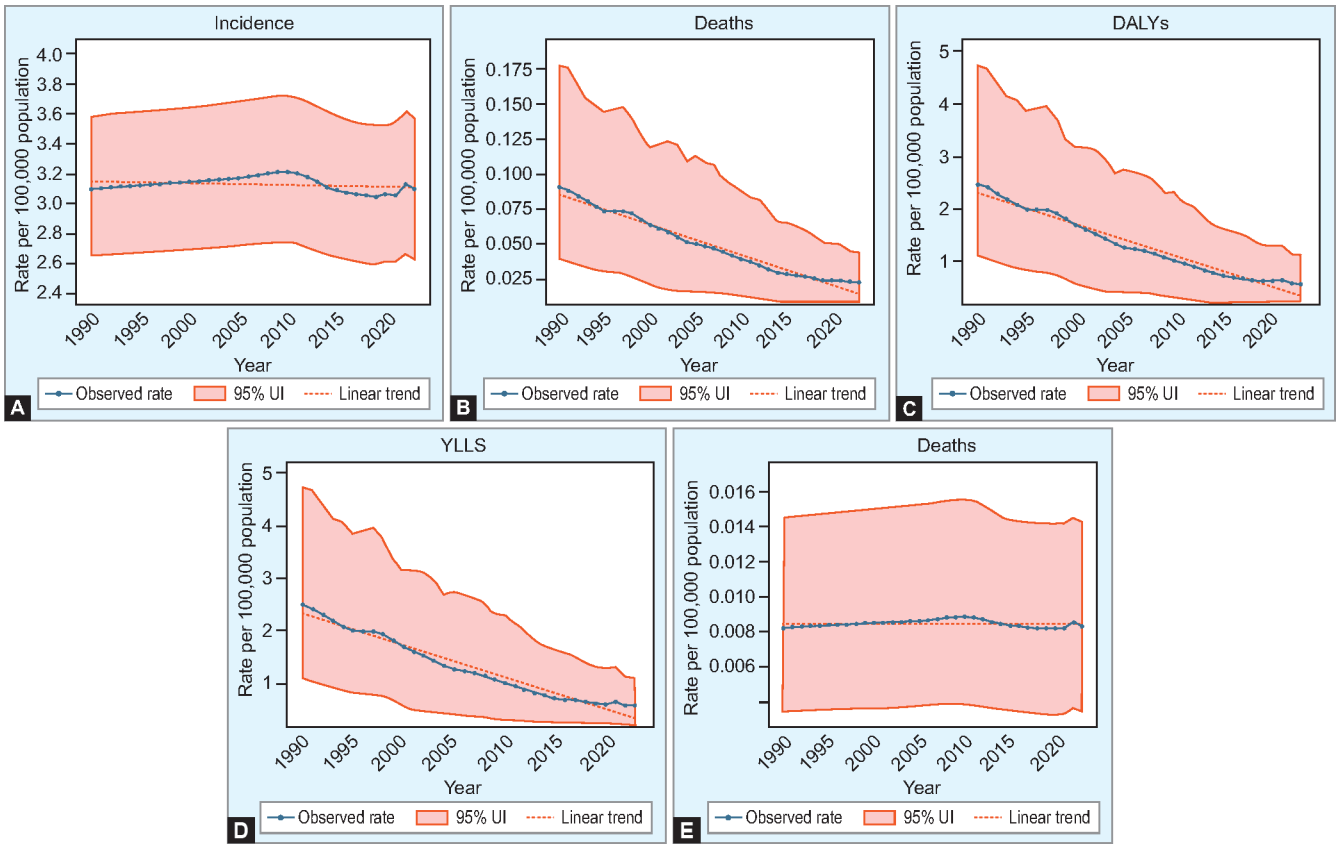
All analyses were performed using Python 3.10 (libraries: Pandas 2.0.3, NumPy 1.24.3, Statsmodels 0.14.0, Matplotlib 3.7.2, Seaborn 0.12.2) in Google Colaboratory. The analysis Python code and the required secondary data set to upload during code execution (updated for use from the primary dataset) are publicly available at https://doi.org/10.5281/zenodo.18000234 to ensure full reproducibility.

Results

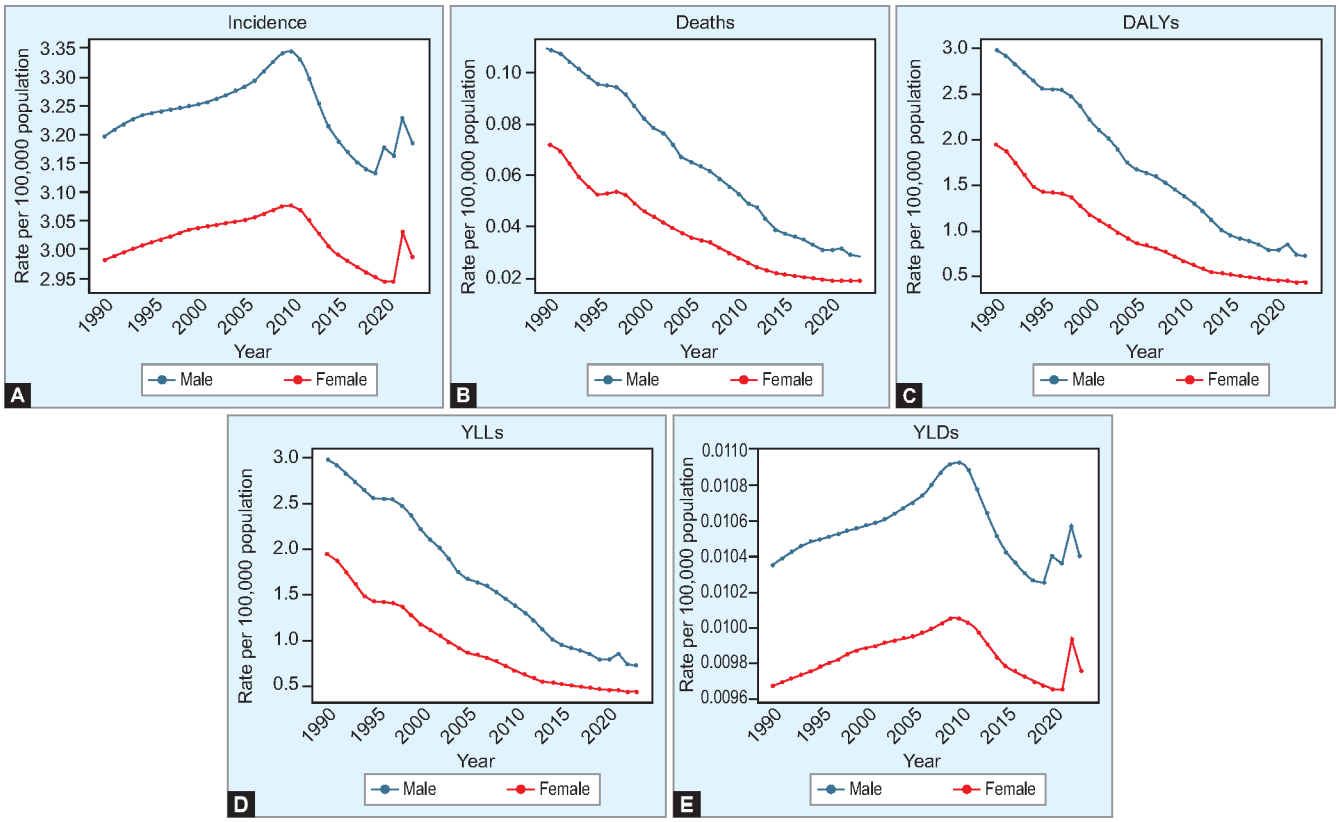
Figure 1 shows the temporal trends of national GN from 1990 to 2023. Between 1990 and 2023, India experienced substantial declines in acute GN mortality and DALYs. The ASR incidence remained stable at 3.09 per 100,000 in 2023 (EAPC −0.05%, 95% CI −0.12 to 0.01, $p = 0.123$), similar to 1990 levels. In contrast, the death rate declined dramatically from 0.091 per 100,000 in 1990 to 0.023 in 2023 (EAPC −4.42%, 95% CI −4.59 to −4.24, $p < 0.001$), representing a 75% reduction. DALYs similarly decreased from 2.49 to 0.58 per 100,000 (EAPC −4.41%, 95% CI −4.59 to −4.24, $p < 0.001$), driven predominantly by reductions in premature mortality (YLLs: EAPC −4.79%, $p < 0.001$) rather than disability (YLDs: EAPC 0.00%, $p = 0.908$). The YLD rates remained relatively constant and low throughout the study period (approximately 0.010 per 100,000), indicating that nonfatal disability burden has not undergone significant change (Fig. S1). These trends collectively demonstrate a sustained improvement in mortality outcomes with stable incidence and minimal change in long-term disability. The divergent trajectories of stable incidence but declining mortality indicate substantial improvements in acute GN case-fatality rates over the three-decade period. Figure S2 shows the age-specific pattern of GN. The 50–69-year age group accounted for the highest proportion of incidence (27.4%), DALYs (24.4%), and YLDs (27.9%). Individuals aged ≥70 years contributed the largest share of deaths (80.1%) and DALYs (60.0%), whereas those <14 years accounted for <5% of total DALYs.

On gender specific analysis, males showed a higher burden across all GN metrics throughout 1990–2023 (Fig. 2). In 2023, male-to-female ratios were 1.44 for incidence (3.65 vs 2.53 per 100,000), 1.56 for deaths (0.028 vs 0.018 per 100,000), and 1.52 for DALYs (0.74 vs 0.49 per 100,000). Temporal trends were similar between sexes, with both experiencing significant mortality declines (males: EAPC −4.51%, 95% CI −4.69 to −4.34, $p < 0.001$; females: EAPC −4.32%, 95% CI −4.52 to −4.13, $p < 0.001$) and stable incidence (males: EAPC −0.06%, $p = 0.684$; females: EAPC −0.04%, $p = 0.782$). The parallel trajectories suggest that improvements in acute renal care have benefited both sexes equally, though the persistent sex disparity in absolute burden indicates differential baseline risk that has remained unchanged over three decades.

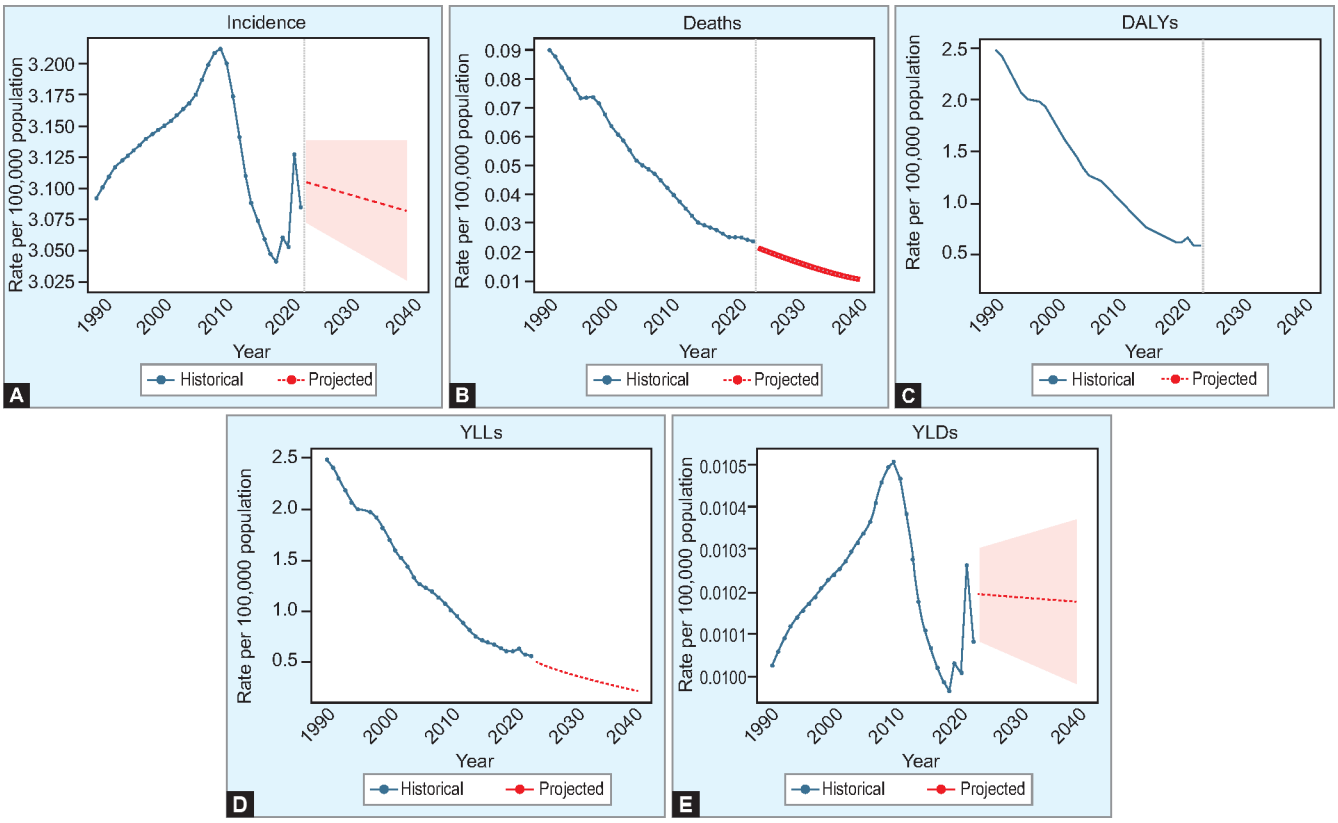
On future trend analysis, GN in India is expected to show divergent trends in ASR versus absolute case numbers through 2040 (Fig. 3). ASR incidence rates are projected to remain stable at approximately 3.06 per 100,000 (95% CI 2.58–3.57), while death rates are expected to decline further to 0.011 per 100,000 (95% CI 0.004–0.021) by 2040, representing a 52% reduction from 2023. DALY rates are projected to decrease from 0.58 to 0.26 per 100,000 (95% CI 0.10–0.51). However, due to population growth and demographic shifts, absolute incident cases are projected to increase from 41,200 in 2023 to 48,720 in 2040 (18% increase), and annual DALYs are projected to rise from 48,950 to 58,300 despite declining age-standardized rates. This discordance between improving rates and rising absolute burden reflects India's expanding and aging population, which will



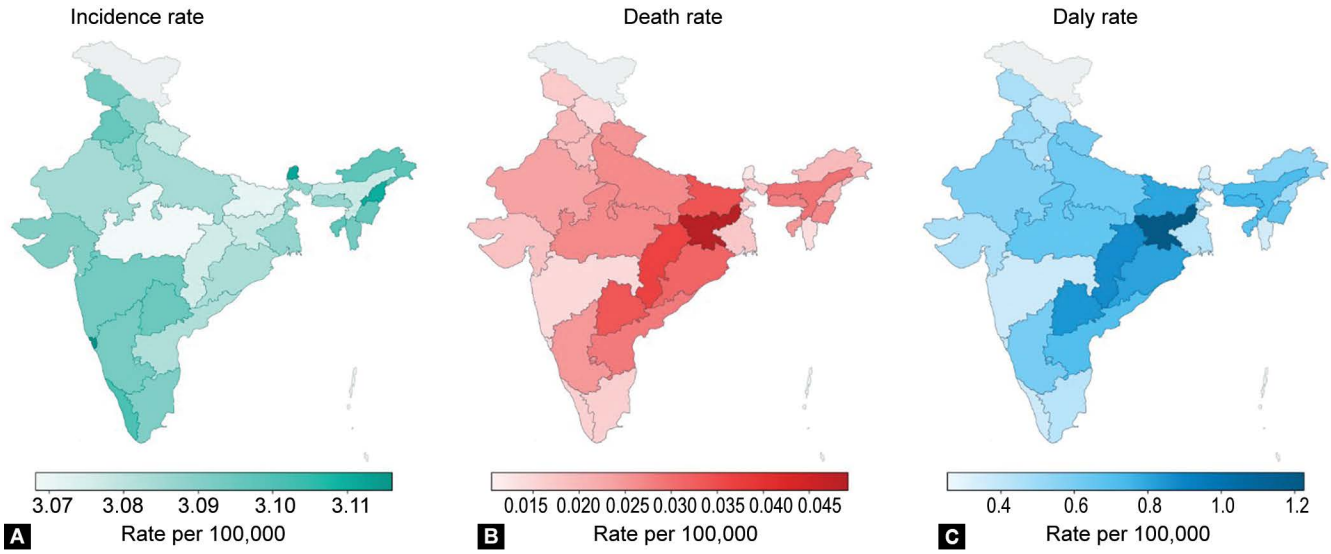
Figs 1A to E: Historical trends for acute glomerulonephritis in incidence, death, DALY, YLL, and YLD from 1990 to 2023



Figs 2A to E: Historical gender wise trends for acute glomerulonephritis in incidence, death, DALY, YLL, and YLD from 1990 to 2023



Figs 3A to E: Future projections for acute glomerulonephritis till 2040 in incidence, death, DALY, YLL, and YLD from 1990 to 2023



Figs 4A to C: Subnational-level snapshot for incidence, death, and DALY

place increasing demands on renal healthcare services even as case-fatality continues to decline.

Substantial state-level heterogeneity in GN burden was observed across India in 2023 (Fig. 4). Age-standardized death rates ranged 4.5-fold from 0.011 per 100,000 in Goa to 0.049 per 100,000 in Jharkhand. The five states with the highest mortality burden were Jharkhand (0.049), Chhattisgarh (0.037), Bihar (0.034), Telangana (0.034), and Odisha (0.031 per 100,000), predominantly clustered in eastern and central India. Similarly, DALY rates varied from 0.26 to 1.23 per 100,000, with eastern states demonstrating disproportionately high DALY burden. In contrast, incidence rates showed minimal interstate variation (3.07–3.12 per 100,000), suggesting differential case-fatality rather than differential disease occurrence.

Discussion

Acute glomerulonephritis in India is undergoing a clear epidemiological transition, characterized by declining mortality alongside stable incidence, suggesting improvements in acute care delivery without

commensurate advancements in primary prevention. The significant reduction in mortality and DALY rates from 1990 to 2023, predominantly attributable to reductions in premature death, aligns with broader trends in noncommunicable disease (NCD) control in low- and middle-income countries (LMICs).[12,13] However, the absence of a substantial decline in incidence and YLD rates indicates that upstream drivers, which included untreated streptococcal infections, environmental nephrotoxins, and limited access to early immunosuppressive therapy, continue to fuel disease onset.[14,15] This dual phenomenon, in which mortality falls, but disability persists, reflects a shift from acute fatality to chronic survivorship, thereby imposing a sustained burden on renal replacement services and the health financing system.

Comparison with Global and Regional Trends

The trends observed in India are consistent with patterns reported across South Asia and other LMICs, where glomerular diseases remain a leading cause of chronic kidney disease (CKD) despite declines in acute mortality.[16,17] Unlike high-income countries, where the incidence of GN has declined due to effective infection control, early biopsy programs, and immunomodulatory therapy access, India's stable incidence curve suggests persistent exposure to preventable risk factors.[18,19] The higher disease burden in males, as observed in our analysis, is also reflected in prior studies attributing sex differences to greater environmental exposure, occupational toxin contact, and possible hormonal influences on immune regulation.[18,20] This reinforces the need for region-specific strategies rather than adopting Western clinical models.

Health System and Policy Implications

The persistence of GN incidence despite improvements in mortality underscores a structural gap in India's kidney care model, where health policies have primarily focused on dialysis and transplant expansion rather than primary prevention and early detection.[21] As an LMIC with constrained health budgets and out-of-pocket expenditure exceeding 60% of total health spending,[22] India must reorient its renal care policy toward upstream interventions. This includes strengthening primary care pathways, integrating GN screening within existing NCD programs, expanding access to kidney biopsy and immunosuppressants under national schemes, and investing in public awareness regarding postinfectious glomerulonephritis. These interventions are critical not only for India but also for other South Asian and African LMICs where GN frequently affects young adults and contributes to long-term socioeconomic loss.

Another noteworthy finding is the subnational disparity in our analysis. We report marked geographic clustering of acute GN mortality in eastern and central states, where death rates exceeded the national average by 2- to 4-fold. This reflects disparities in healthcare access and renal care infrastructure rather than differential disease occurrence, as incidence rates remained uniform across states. These findings align with known health inequities in India, where Jharkhand, Chhattisgarh, Bihar, and Odisha have substantially lower per capita health expenditure and nephrology workforce density. The divergence between uniform incidence and heterogeneous mortality suggests that acute GN deaths are largely preventable, underscoring the need for targeted investments in emergency renal care capacity and dialysis infrastructure in high-burden states to achieve geographic equity in kidney health outcomes.

Future Trends and Global Health Relevance

Our projections indicate that while age-standardized rates may stabilize or decline modestly by 2040, the absolute number of cases will continue to rise due to demographic expansion and population aging. This trajectory mirrors the projected global rise in CKD burden and signifies that GN will remain a substantial contributor to kidney failure in LMICs unless preventive strategies are urgently implemented.[9] Achieving Sustainable Development Goal 3.4, which targets a one-third reduction in premature mortality from noncommunicable diseases by 2030, will require India to transition from a reactionary to a prevention-oriented GN policy framework.[23] Importantly, the methodological approach of combining epidemiologic trends with population projections provides an evidence-based model that can be adopted by other LMICs to forecast resource needs and guide kidney health planning. We highlight the strength of the study as the first comprehensive national and subnational acute GN burden and future projection of India. Notably, there was also some inherent limitation of the study. There is incomplete vital registration coverage (estimated at 86% for deaths, with significant urban-rural disparities) in India. Hence, GBD estimates involve substantial statistical modeling and should be interpreted with appropriate caution.

Conclusion

In summary, India's success in reducing glomerulonephritis-related mortality demonstrates effective acute care delivery. However, the stable incidence and rising disability burden indicate that mortality reduction has not translated into disease prevention. Glomerulonephritis should be recognized as a sentinel marker of health system performance in LMICs, a disease where preventable infections, inequitable access to diagnostic services, and delayed treatment converge to shape renal health outcomes. A paradigm shift toward community-level screening, environmental risk mitigation, universal biopsy access, and affordable immunosuppressive therapies is essential to reduce future burden. Without decisive policy action, the gains in survival may paradoxically fuel downstream growth in CKD and end-stage kidney disease, overwhelming dialysis and transplant capacity in India and similar LMIC contexts.

Declarations

Acknowledgments

This study utilized Global Burden of Disease (GBD) 2023 data.

Conflicts of Interests

None.

Source of Funding

None.

Availability of Data and Material

The clinical data and the study materials are available from the corresponding author on reasonable request.

Patient Consent Statement

None.

Ethical Clearance

Not applicable for this article. This study utilized Global Burden of Disease (GBD) 2023 data.

Author Contributions

All authors, HSM, SC, SP, SS, and NPS, were involved in the literature search, planning, conducting, and editing of the study, and in writing the original draft of the manuscript. All the authors have agreed with the submitted manuscript. SS is the corresponding author and guarantor for all.

Supplementary Material

The Supplementary Figures S1 and S2 are available online on the journal website.

Fig. S1: Trends of percentage of YLL and YLD due to acute glomerulonephritis over 1990–2023

Fig. S2: Age wise distribution of all metrics due to acute glomerulonephritis of 2023

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