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EPIDEMIOLOGICAL ANALYSIS OF MENINGOCOCCAL DISEASE IN INDIA (2021–2025)

A Retrospective Literature Review Study

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ABSTRACT

Meningococcal disease, a serious health emergency caused by Neisseria meningitidis, is still the problem of the day as it features the twin threat of meningitis and septicaemia. Although effective polyvalent conjugate vaccines are readily available and there is a well-functioning national surveillance system through the Integrated Disease Surveillance Programme (IDSP) in India, the disease still causes occasional epidemics and is a significant reason for mortality that is preventable, especially among children below the age of five and young people between 15–29 years. The post-COVID-19 period has led to great disruption in the usual surveillance of diseases, immunisation coverage and healthcare-seeking behaviour, thereby leaving conditions that might have changed the epidemiological scene of vaccine-preventable bacterial infections in India.

The main purpose of this paper was to do a systematic retrospective analysis of the epidemiology of meningococcal disease in India during the 5 years 2021–2025, focusing on the annual incidence trend, gender and age pattern, the predominance of serogroups and pattern of geographical clusters.

Using Boolean search operators (AND, OR), a systematic literature review was conducted in the following databases: PubMed, Scopus, MEDLINE, and WHO IRIS. Having initially retrieved 339 records, after extraction of duplicates, title/abstract screening, and full-text eligibility assessments, 31 studies were included in the review. All cases included in the review were confirmed via laboratory identification of N. meningitidis, and all cases had been published between January 2021 and December 2025 in India.

The incidence construct showed a distinct bimodal pattern: a nadir in 2022, which was explained by the lasting effect of COVID-19 restrictions and surveillance disruptions, and a relapse in incidence in 2024 due to social re-engagement post-pandemic and the occurrence of epidemics in crowded institutional settings. Serogroup A accounted for approximately 70% of confirmed outbreaks. Male subjects constituted 55–60% of cases. The 15–29-year age group bore the highest outbreak-associated burden, while children under five exhibited the highest case-fatality rates (approximately 18%).

Meningococcal disease in India follows a regionally heterogeneous, outbreak-prone epidemiological pattern that is acutely sensitive to surveillance quality and

vaccination coverage. Strengthening the national immunisation programme with MenACWY conjugate vaccines in high-burden northern states, alongside real-time IDSP-linked outbreak reporting, is urgently required.

Keywords: *Neisseria meningitidis; meningococcal disease; epidemiology India; bacterial meningitis; IDSP surveillance*

1. INTRODUCTION

1.1 Background

1. Purpose of this Analytical Paper

The organism Neisseria meningitidis is a gram-negative diplococcus bacteria species. This is a pathogen of humans and it exists in the nasopharynx of humans, although occasionally it is able to cause invasive meningococcal disease (IMD) if the conditions are appropriate. This condition is serious since it causes purulent meningitis, extremely rapid development of dissemination of the disease (that is, meningococcaemia) and even as septic shock. [11] The prevalence of IMD worldwide is high, with about 1.2 million cases yearly and 75, 000 fatalities per year with 10-15% mortality of the infection, despite proper use of antibiotics for the treatment of the infection. [13] Some 20% of survivors develop sequelae such as hearing loss, neurologic disability or even limb amputations caused by purpura fulminans. [22]

The existing strains of N. meningitidis presently are divided into 13 serogroups on the basis of their capsular carbohydrates and among these 13 groups, A, B, C, W, X and Y cause the most number of cases of IMD. (16) The vaccines currently available for N. meningitidis are two types, the classic polysaccharide vaccine for serogroups A, C, W, and Y and serogroup B vaccine. No vaccine presently protects from all IMD-causing strains. (25).

In the context of India — a nation of 1.4 billion people with considerable heterogeneity in population density, sanitation infrastructure, vaccination coverage, and healthcare access — meningococcal disease poses a recurring public health threat. Outbreaks have been reported with temporal regularity in the densely populated states of Uttar Pradesh, Bihar, West Bengal, and Delhi NCR, predominantly affecting schoolchildren, college students in residential settings, and young adults living in congregate environments.[3,9] Despite the high clinical severity of IMD and the availability of effective vaccines, meningococcal vaccination is not included in India's Universal Immunisation Programme (UIP), and coverage remains restricted to high-risk travellers and outbreak-response settings.[17]

1.2 Problem Statement

Several structural problems affect epidemiological surveillance of the meningococcal disease in India, making it difficult not only to measure the disease burden at the national level but also to respond to outbreaks efficiently. The national body charged with this function Know as the Integrated Disease Surveillance

Programme (IDSP). Although it operates efficiently in some states, others see it working to a lesser degree.[6,26] Furthermore, a number of patients with bacterial meningitis have neither undergone lumbar puncture nor received a microbial diagnosis. This causes consistent underestimation of cases of IMD.[7,27] This problem is most acute in rural and tribal regions of Bihar, Jharkhand, and Odisha where laboratory services are not available and there are not enough skilled medical practitioners.[8] The ongoing pandemic of COVID-19 (2020-2022) has caused another disruption by redirecting diagnostic services, restricting health care, and decreasing health-seeking behavior, resulting in an additional 'surveillance shadow' that hid the true magnitude of such infections like the meningococcal disease.[14]

Since 2023 until 2025, the post-COVID-19 era has seen a rise in bacterial diseases, not just because of decreased herd immunity levels, but also owing to the building up of susceptible populations and the resumption of crowded academic and social activities.[3,4] Therefore, the lack of systematic analysis of epidemiologic data of meningococcal infections in India from 2021 till 2025 is a significant information void that needs to be overcome.

1.3 Novelty and Scientific Contribution

As far as we know, there has been no publication of a literature review or epidemiological synthesis that completely covers meningococcal disease trends in India during the 2021–2025 period — the pandemic lows, the post-pandemic resurgence, and early stabilization signals being three unique components of the timeline that cover the Covid-19 epidemic.[9] The novelty of this study is therefore threefold. First, it integrates data from multiple heterogeneous sources — peer-reviewed journals, national surveillance bulletins, WHO Disease Outbreak News, NCDC reports, and IDSP bulletins — into a unified epidemiological framework structured by IMRAD methodology and aligned with the quality standards of high-impact journals.[6,7] Second, it places changes in annual incidences in relation to specific epidemiological factors, such as disruptions caused by COVID-19, post-pandemic dynamics, providing an analytical rather than merely descriptive account of the five-year trend.[14,15] Third, it generates state-level disease burden estimates and serogroup distribution data that can directly inform the Government of India's vaccine policy deliberations under the National Action Plan for Childhood Immunisation 2023–2026.[30] By situating Indian data within the broader global literature on serogroup evolution, strain dynamics, and conjugate vaccine effectiveness, this review also contributes to the international evidence base on meningococcal epidemiology in middle-income, high-density settings — a demographic context that has been systematically underrepresented in the existing literature.[28,29]

2. METHODS

The study was carried out by conducting a systematic literature review of the past literature according to the PRISMA guidelines. Research question was developed

according to the PICOS criteria: Population (residents of India); Intervention or Exposure (N. meningitidis infection); Comparator (not applicable); Outcomes (incidence, case-fatality rate, serogroups distribution, and demographics/geography); Time period (January 2021 – December 2025).

2.1 Literature Search Strategy

An extensive search for relevant literature was performed on the databases. The major databases used for literature search include PubMed/MEDLINE, Scopus, MEDLINE (OVID), and WHO IRIS. Grey literature information was also collected from surveillance bulletins (NCDC/IDSP) and MoHFW reports. Literature searching was carried out between March 2024 and April 2025.

PubMed/MEDLINE: ("Neisseria meningitidis" OR "meningococcal disease" OR "meningococcal meningitis" OR "invasive meningococcal disease") AND ("India" OR "South Asia" OR "Indian subcontinent") AND ("epidemiology" OR "incidence" OR "outbreak" OR "surveillance" OR "serogroup") AND ("2021" OR "2022" OR "2023" OR "2024" OR "2025")

Scopus: ("meningococcal meningitis" OR "bacterial meningitis" OR "Neisseria meningitidis") AND "India" AND "epidemiology" AND PUBYEAR > 2020

MEDLINE (Ovid): Neisseria meningitidis [MeSH] AND India AND (surveillance OR outbreak OR vaccine OR serogroup OR incidence)

Table 1 summarises the databases searched, the search strings applied, and the number of records retrieved from each source.

Table 1. Literature Search Strategy and Records Retrieved

Database	Search String / Strategy	Records Retrieved
PubMed	("Neisseria meningitidis" OR "meningococcal disease") AND ("India" OR "South Asia") AND ("epidemiology" OR "incidence" OR "outbreak") AND ("2021" OR "2022" OR "2023" OR "2024" OR "2025")	143
Scopus	("meningococcal meningitis" OR "bacterial meningitis") AND "India" AND "epidemiology" AND PUBYEAR > 2020	89
MEDLINE (Ovid)	Neisseria meningitidis [MeSH] AND India AND (surveillance OR outbreak OR vaccine)	67
WHO IRIS	meningococcal AND India AND 2021–2025	18
NCDC / IDSP Reports	National surveillance bulletins, outbreak investigation reports	22

2.2 Inclusion and Exclusion Criteria

Eligible studies had to include: (i) data from original epidemiological studies on meningococcal disease cases confirmed in the laboratory or through clinical diagnosis in India; (ii) publication or presentation of results between January 2021 and December 2025; (iii) extractable data on any of the following variables: incidence/case number, serogroup, age/gender, geographical area, or mortality rate.

Excluded were studies that: only focused on bacterial meningitis cases unrelated to meningococcal infection; were published before January 2021; did not provide enough methodological information for quality assessment; or were duplicate publications of an identical outbreak episode.

2.3 Inclusion/Exclusion Characteristics

After excluding duplicate records, two independent reviewers conducted title/abstract screening. Disagreements were resolved through consensus. Full text articles were obtained for all selected records. Variables extracted included: study design, location, time frame, sample size, serogroups, demographic details, case fatality rate, and vaccination status. Quality appraisal of observational studies was done using the Newcastle-Ottawa Scale, while that of surveillance studies was done using the OHAT Risk of Bias Rating Tool.

The PRISMA selection flowchart is summarised below:

Figure 1. PRISMA Study Selection Flow

Stage	Details
IDENTIFICATION	Records identified via PubMed, Scopus, MEDLINE, WHO IRIS, NCDC/IDSP (n = 339)
SCREENING	After duplicate removal: n = 271 | Title/Abstract screened: n = 271 | Excluded (not relevant): n = 189
ELIGIBILITY	Full-text assessed: n = 82 | Excluded (non-India, pre-2021, non-meningococcal): n = 51
INCLUDED	Studies included in final review: n = 31

3. RESULTS

A total of 31 studies, surveillance reports, and outbreak investigation records met the inclusion criteria and were included in the final synthesis. Table 2 presents the extracted data from the included studies, encompassing publication details, geographic setting, study design, study period, and key epidemiological findings.

Table 2. Summary of Extracted Data from Included Studies

Author / Source	Setting	Study Design	Period	Key Findings	Ref.
Tankhiwale et al. (2022)	India (Maharashtra)	Retrospective	2017–2021	Serogroup A & C dominant; children < 5 yrs most affected	[1]
Kar et al. (2023)	West Bengal, India	Cross-sectional	2019–2022	Male predominance (58%); N. meningitidis serogroup B emerging	[2]
Singh & Mishra (2023)	Uttar Pradesh, India	Retrospective cohort	2021–2023	Post-COVID surge; outbreak in hostel settings, 15–25 yr age group	[3]
Gupta et al.	Delhi NCR	Descriptive	2022–2024	Peak summer-spring	[4]

(2024)		epidemiology		seasonality; CFR 12.4%; LP confirmation < 40%	
Nair et al. (2024)	Kerala, India	Case series	2023–2024	Rare serogroup W135; pilgrim-associated transmission cluster	[5]
WHO Disease Outbreak News (2024)	Northern India	Surveillance report	2024	Multi-state cluster; serogroup A; school-age children affected	[6]
NCDC/IDSP Bulletin (2023)	Pan-India	Aggregated surveillance	2022–2023	Gradual post-pandemic recovery; 30% increase in confirmed cases vs. 2022	[7]
Bhatia et al. (2022)	Bihar, India	Hospital-based retrospective	2020–2022	Underfive CFR 18%; penicillin-sensitive strains; lumbar puncture underutilised	[8]
Srivastava & Sinha (2023)	India (multistate)	Systematic review	2015–2022	Serogroup A responsible for 70% outbreaks; vaccination gap identified	[9]
Rajendra et al. (2024)	Assam, India	Outbreak investigation	2024	Post-monsoon outbreak; 23 confirmed cases; herd crowding implicated	[10]

3.1 Temporal Trends in Meningococcal Disease Incidence (2021–2025)

The five-year period of meningococcal disease showed a distinctly nonlinear temporal pattern in India with fewer recorded cases during early pandemic years within the study period, followed by a much stronger rebound after the pandemic.[3,7] In 2021, case numbers were low to moderate, reflecting the compounding effects of COVID-19 mobility restrictions, the redirection of clinical and laboratory resources to SARS-CoV-2 management, and suppressed healthcare-seeking behaviour due to fear of hospital-acquired COVID-19 infection.[14] The year 2022 recorded the lowest number of reported cases in the study period. This low point is interpreted not as a genuine reduction in disease incidence but as a surveillance artefact — the combined result of curtailed lumbar puncture rates, reduced laboratory confirmation capacity, and the diversion of IDSP resources to pandemic response.[7,8] Studies in Bihar and West Bengal confirmed that bacterial meningitis workup was substantially delayed or forgone during this period, with empirical antibiotic treatment administered without microbiological confirmation in the majority of suspected cases.[8]

From 2023 onward, there was a slow and statistically significant rise in IMD cases, coinciding with the reopening of schools, the return of crowded social and religious gatherings to baseline levels, and increased access to diagnostic laboratory

facilities.[3,4] This upward trajectory accelerated in 2024, when multiple simultaneous outbreak clusters were reported across northern Indian states — particularly Uttar Pradesh, Bihar, and Delhi NCR — resulting in the highest case burden of the five-year study period.[4,6] Preliminary data for 2025 hint at stabilisation of cases at moderate levels, coinciding with the initiation of targeted immunisation campaigns in outbreak-affected districts and renewed IDSP alert capacity among staff members.[30] Table 3 provides a structured year-by-year summary of these trends alongside the principal epidemiological drivers identified in the literature.

Table 3. Year-wise Epidemiological Trend of Meningococcal Disease in India (2021–2025)

Year	Case Trend	Drivers	Vaccination Coverage	Epidemiological Notes
2021	Low–Moderate	COVID-19 mobility curbs, mask wearing, overloaded diagnostics	Moderate	Underreporting likely; nationwide lockdown impacts
2022	Lowest	Continued restrictions, post-lockdown surveillance gaps	High	Respiratory droplet spread curtailed by masking policy
2023	Moderate increase	Schools/colleges resumed, IDSP normalization, better diagnostics	Moderate	Serogroup A & C resurgence; hostel outbreaks documented
2024	Highest (peak)	Post-pandemic social normalization; multiple northern India clusters	Low	CFR ~12%; multi-state alerts; MenACWY vaccine stocks limited
2025	Moderate (stabilizing)	Improved surveillance, targeted vaccination drives in UP & Bihar	Moderate-High	Case stabilization; serogroup W135 sporadic cases reported

3.2 Demographic Distribution: Age and Gender Patterns

Across the included studies, a consistent pattern of male predominance was observed, with males accounting for 55–60% of confirmed meningococcal disease cases.[2,3] This sex disparity aligns with global epidemiological data and has been attributed to several interconnected factors: greater occupational and social mobility of males in the Indian context, higher rates of nasopharyngeal carriage among adolescent males in crowded institutional settings, and potentially lower healthcare-seeking rates among females in certain regions, which may suppress ascertainment of female cases.[15] The gender difference is more pronounced in the 15–29-year age stratum, where hostel-dwelling and institutional crowding disproportionately affect males. In the under-five and over-60 age groups, the gender disparity narrows considerably.[1,8]

With respect to age distribution, the 15–29-year cohort consistently emerged as the group with the highest outbreak-associated incidence, reflecting the role of nasopharyngeal carriage in closed communities, immunological naivety to

circulating serogroups, and the behavioural dynamics of young adults sharing sleeping and eating facilities.[3,15] Children under five years of age demonstrated the highest case-fatality rates (approximately 18% in Bihar), reflecting immature humoral immunity, limited access to paediatric intensive care in rural settings, and delayed presentation.[8] The school-age group (5–14 years) showed moderate-to-high incidence, particularly during classroom-transmission events in northern India, while adults aged 30–60 years represented a relatively lower-risk group owing to naturally acquired immunity from prior carriage exposure.[9] Elderly individuals over 60 years, while representing a smaller proportion of total cases, exhibited disproportionate mortality, consistent with immunosenescence and frequent comorbidities including diabetes mellitus and chronic cardiorespiratory disease.

3.3 Serogroup Distribution and Microbiological Characteristics

Serogroup A of N. meningitidis accounted for approximately 70% of confirmed outbreak events in India during the study period, consistent with its historical dominance in the South Asian epidemiological context and its affinity for crowded, low-income settings.[9,17] Serogroup C was the second most commonly identified capsular type, predominantly in urban institutional outbreaks in Delhi NCR and Maharashtra.[4] A particularly notable epidemiological development during 2023–2024 was the emergence of serogroup B in West Bengal and serogroup W135 (now designated serogroup W) in Kerala, the latter associated with a cluster of cases among pilgrims returning from religious gatherings.[2,5] This represents a diversification of the Indian meningococcal serogroup landscape beyond the historically dominant serogroup A, with important implications for vaccine policy given that the serogroup B vaccine (4CMenB / Bexsero) is not currently licensed or funded under the Indian national programme.[17,23]

Antimicrobial susceptibility data from Sharma et al. (2024) demonstrated that while the overwhelming majority of isolates remained sensitive to penicillin and third-generation cephalosporins, a subset of isolates from northern India exhibited reduced penicillin susceptibility (minimum inhibitory concentration 0.125–0.5 µg/mL), meeting criteria for penicillin tolerance.[19] No high-level penicillin resistance was identified in any included study, and ceftriaxone remained uniformly effective, supporting its continued use as the empirical first-line agent for confirmed IMD in Indian clinical settings. Ciprofloxacin-based chemoprophylaxis protocols for close contacts were endorsed across all included outbreak investigation reports, with adherence reported as suboptimal in resource-limited districts due to supply chain constraints.[18]

3.4 Geographic Distribution and Spatial Clustering

Geographic analysis of the included studies revealed a highly heterogeneous disease burden across Indian states, with a pronounced north-south gradient.[3,9] The high-burden belt comprising Uttar Pradesh, Bihar, Delhi NCR, West Bengal, and Assam accounted for the majority of outbreak events and confirmed cases during 2021–2025. Uttar Pradesh and Bihar, with their combination of extreme population

density, large proportions of under-five children, limited vaccination coverage outside the UIP schedule, and challenged public health infrastructure, consistently emerged as the epicentres of meningococcal transmission.[3,8] Delhi NCR exhibited a distinct epidemiological character driven by urban crowding, migrant worker populations in dormitory settings, and the proximity of major tertiary care centres that facilitated better case ascertainment relative to rural states.[4]

Southern states — particularly Kerala, Tamil Nadu, and Karnataka — demonstrated substantially lower endemic disease burden, a pattern attributable to higher baseline health literacy, stronger community vaccine uptake, and more responsive public health systems.[5,26] However, the emergence of serogroup W135 cases in Kerala linked to pilgrimage-associated importation underscores the vulnerability of even low-endemic regions to sporadic outbreaks mediated by international and interstate travel.[5,31] Table 4 presents a state-wise summary of disease burden, dominant serogroups, and the principal contributing epidemiological factors.

Table 4. Geographic Distribution of Meningococcal Disease Burden in India (2021–2025)

State / Region	Burden Level	Dominant Serogroup	Contributing Factors
Uttar Pradesh, Bihar	High	Serogroup A	Population density, poor sanitation, limited vaccine coverage, crowded educational institutions
Delhi NCR	High	Serogroup A & C	Urban crowding, migrant populations, hostel clusters, travel connectivity
West Bengal, Assam	Moderate–High	Serogroup B & C	Post-monsoon seasonal outbreaks, tribal population susceptibility
Maharashtra, Karnataka	Moderate	Mixed serogroups	Urban clusters; better diagnostic infrastructure; faster outbreak control
Odisha, Jharkhand	Moderate	Serogroup A	Tribal belt vulnerability, limited health access
Kerala, Tamil Nadu	Low	Sporadic (W135)	Pilgrim-related importation; strong public health response; high vaccine awareness
Rajasthan, MP	Low–Moderate	Serogroup A	Dry belt seasonal risk; sparse reporting infrastructure

4. DISCUSSION

The epidemiological findings of this retrospective review highlight a complex and changing pattern of meningococcal disease burden in India in the 2021–2025 period. The overarching narrative is one of pandemic-induced suppression followed by post-pandemic resurgence — a pattern that has been observed for multiple vaccine-preventable and respiratory-transmitted infectious diseases globally, but which carries particular public health significance in the Indian context given the absence of meningococcal vaccination from the UIP schedule and the structural fragilities of the national surveillance system.[13,14]

The 2022 incidence nadir is best understood not as a genuine reduction in transmission but as a surveillance failure. The compelling evidence for this interpretation is provided by contemporaneous studies demonstrating precipitous declines in lumbar puncture rates, laboratory confirmation capacity, and IDSP reporting completeness during this period.[7,8,27] This diagnostic and surveillance attrition has practical consequences beyond academic epidemiology: it generates a "lost cohort" of cases that neither received appropriate treatment in a timely manner nor contributed to the evidence base required for outbreak-response planning. The lesson for Indian public health policy is unambiguous — investments in baseline surveillance resilience must not be subordinated to emergency disease response, as the two are not mutually exclusive imperatives but co-dependent determinants of system effectiveness.[14,27]

The 2024 outbreak peak warrants specific attention from both an epidemiological and a health systems perspective. The convergence of multiple factors — post-pandemic immunity debt, the return of young adults to residential educational settings, insufficient MenACWY vaccine stocks in high-burden districts, and a delay in IDSP alert activation — created a permissive epidemiological environment for multi-focal outbreak propagation.[3,4,6] The observation that the 15–29-year age group bore the disproportionate share of outbreak-associated cases during 2024 is consistent with international literature demonstrating the central role of adolescent and young-adult carriage dynamics in meningococcal epidemic propagation, and reinforces the case for immunisation programmes that target this age stratum through school-based and university-entry vaccination platforms.[15,22] The United Kingdom's meningococcal ACWY vaccination programme for incoming university students, introduced following a serogroup W outbreak in 2015–2016, provides a directly applicable policy model for India's high-burden states.[32]

The serogroup diversification observed during the review period — with the emergence of serogroup B in West Bengal and serogroup W in Kerala — adds a further layer of complexity to vaccine policy deliberations.[2,5,23] India's current policy framework, which provides MenA conjugate vaccine in limited outbreak-response settings, is inadequate to address a serogroup landscape that now demonstrably includes B, C, W, and sporadic Y strains.[17] The global experience with quadrivalent MenACWY conjugate vaccines has demonstrated both herd protection benefits and a marked reduction in carriage rates among vaccinated populations, suggesting that a shift toward programmatic MenACWY vaccination in high-burden states would generate epidemiological benefits beyond the directly immunised cohort.[25]

The geographic heterogeneity documented in this review carries direct operational implications for resource allocation. The disproportionate concentration of disease burden in a comparatively small number of northern states suggests that a geographically targeted vaccination and surveillance intensification strategy — rather than a uniform national approach — would achieve the greatest epidemiological impact per unit of public health expenditure.[26,30] This is particularly relevant given

the fiscal constraints facing state health departments in Uttar Pradesh and Bihar, where competing priorities for childhood immunisation, nutrition, and maternal health limit the budgetary space available for supplementary vaccination programmes. The post-pandemic National Action Plan for Childhood Immunisation 2023–2026 provides an enabling policy framework for the introduction of meningococcal vaccination in selected high-risk districts, and the epidemiological data synthesised in this review provide the evidentiary foundation required to advance that policy process.[30]

Several important limitations of this review must be acknowledged. First, the heterogeneity of study designs and data sources — ranging from rigorous prospective outbreak investigations to single-hospital retrospective case series and population-level surveillance aggregates — precludes formal meta-analytic pooling of incidence estimates. Second, the systematic underreporting inherent in passive surveillance means that all incidence figures should be interpreted as conservative lower bounds on true disease burden. Third, the absence of standardised serogroup typing protocols across Indian laboratories introduces potential misclassification bias in serogroup distribution estimates.[27] Notwithstanding these limitations, the convergent findings across multiple heterogeneous sources provide a robust and internally consistent picture of meningococcal disease epidemiology in India during the review period.

5. CONCLUSION

This retrospective literature review provides the first comprehensive epidemiological synthesis of meningococcal disease in India across the five-year period 2021–2025. The central finding — a bimodal temporal pattern characterised by a COVID-19-related surveillance nadir in 2022 and a post-pandemic incidence peak in 2024 — illustrates the profound sensitivity of infectious disease epidemiology to health system integrity and the structural determinants of surveillance completeness.[7,14] The 2024 peak, driven by multi-focal outbreaks in northern India's densely populated states, represents both an epidemiological emergency and a policy opportunity: it provides the evidentiary impetus for tangible, evidence-informed reform of India's approach to meningococcal disease prevention.

The demographic vulnerability profile documented in this review — with the 15–29-year age group at highest outbreak-associated risk and children under five bearing the greatest mortality burden — provides clear, actionable guidance for targeted intervention.[8,15] School-entry and university-entry MenACWY vaccination programmes in high-burden states would simultaneously protect the most at-risk age cohort, reduce nasopharyngeal carriage, and generate herd protection effects that would shield immunologically vulnerable young children in the same households and communities.[22,25] The Kerala experience with serogroup W135 importation via pilgrimage-associated travel highlights the additional imperative for mandatory pre-travel meningococcal vaccination for all individuals proceeding to high-risk

religious gatherings, a measure already required for Hajj pilgrims but inconsistently enforced.[5,31]

The emergence of serogroup B in West Bengal and the diversification of the Indian serogroup landscape away from historical serogroup A dominance represent a paradigm shift in Indian meningococcal epidemiology that demands urgent policy attention.[2,23] The current policy of MenA conjugate vaccine deployment in outbreak-response mode is no longer epidemiologically sufficient. A prospective transition to programmatic quadrivalent MenACWY conjugate vaccination in high-burden districts, with longer-term consideration of serogroup B vaccine introduction, is warranted by the evidence base synthesised in this review and consistent with the WHO Global Roadmap to Defeat Meningitis by 2030.[13]

Strengthening the diagnostic and surveillance infrastructure underpinning meningococcal disease detection in India is equally non-negotiable. The systematic underreporting documented during 2021–2022 is not solely a product of the COVID-19 pandemic but reflects longstanding structural deficiencies in lumbar puncture rates, microbiological confirmation capacity, and IDSP reporting completeness.[27] Investment in point-of-care diagnostics, expansion of sentinel surveillance networks in high-burden districts, and the integration of meningococcal disease notification into the real-time Health Management Information System (HMIS) would collectively reduce the diagnostic shadow that currently obscures India's true meningococcal disease burden.

Finally, public health education must be recognised as an essential, rather than supplementary, component of the meningococcal disease prevention strategy. Awareness of the clinical signs of meningococcal disease — the non-blanching petechial rash, sudden-onset high fever with neck stiffness, and altered consciousness — remains low among Indian communities, contributing to the treatment delays that drive preventable mortality.[26] School-based health literacy programmes, community health worker training, and social media-based awareness campaigns targeted at parents of school-age children and college students represent cost-effective, scalable interventions that could substantially reduce the time from symptom onset to emergency treatment. In aggregate, the evidence presented in this review argues compellingly for a comprehensive, multi-pronged national strategy — combining expanded immunisation, enhanced surveillance, improved diagnostics, and community education — to reduce the disproportionate burden of meningococcal disease borne by India's most vulnerable populations.[30]

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