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Original Research Paper

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DISEASE HOT SPOT MAPPING FOR HEALTHCARE ACCESS INEQUITY IN RURAL WEST BENGAL (INDIA)

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KEYWORDS :

Disease hot spot mapping is an essential spatial epidemiological approach for identifying healthcare access inequities in rural West Bengal, India. This study aims to integrate geospatial analytics with public health indicators to delineate disease burden clusters and assess their association with disparities in healthcare availability and utilization. Secondary health data on communicable and non-communicable diseases were combined with geo-coded information on healthcare facilities, transportation networks, population density, and socioeconomic deprivation indices. Spatial statistical techniques, including Getis–Ord Gi* hot spot analysis and kernel density estimation, were employed to identify high-risk disease clusters at the block and village levels. The findings reveal pronounced disease hot spots in geographically isolated and socioeconomically dis-advantaged rural pockets, characterized by limited proximity to primary health centers, poor road connectivity, and shortages of skilled health personnel. These inequities disproportionately affect vulnerable populations, including women, children, and the elderly. The study highlights the critical role of spatial decision-support systems in evidence-based health planning and resource allocation. By visualizing mismatches between disease burden and healthcare access, disease hot spot mapping provides actionable insights for targeted interventions, strengthening primary healthcare infrastructure, and advancing equitable healthcare delivery in rural West Bengal.

1) Context & Problem Definition

Healthcare access inequity in rural West Bengal arises from uneven distribution of health infrastructure, services and disease burden across space and population groups. Key inequities include:

- Spatial distribution of facilities: Many rural settlements are farther from Primary Health Centres (PHCs) and Community Health Centres (CHCs) — often >5 km from the nearest facility in hotspot rural pockets. (1)
- Resource and staff shortfalls: Declining specialist availability (e.g., OB-GYN at CHCs) disproportionately affects marginalized and tribal communities. (2)
- Socioeconomic gradients: Poorer districts show lower healthcare quality and accessibility indices. (3)

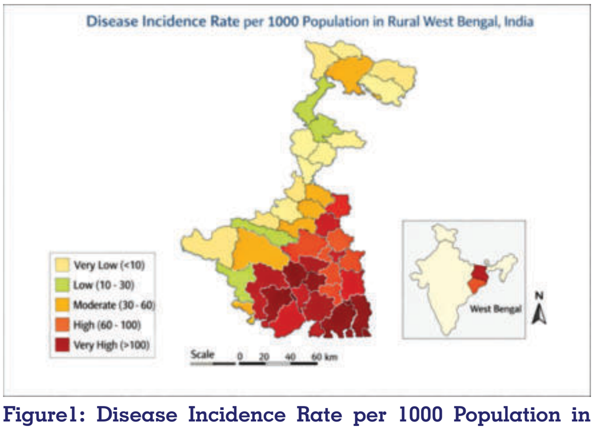

Figure1: Disease Incidence Rate per 1000 Population in Rural West Bengal, India

Disease hot spot mapping is used to spatially identify clusters of elevated disease incidence (Figure1) and overlay these with healthcare access metrics to reveal inequities.

2) Spatial Data & Indicators

Disease hotspot mapping requires integrating multiple datasets:

A. Epidemiological Data

- Case counts (e.g., vector-borne diseases like dengue, malaria).
- Disease surveillance data (NVBDCP, IDSP, hospital records).
- Serotype or pathogen-specific data (e.g., dengue NS1 positives). (4)

B. Healthcare Access Metrics

- Facility density & proximity: distance to nearest PHC/CHC, travel time to care centers(1)
- Service capacity & quality: operating capacity of facilities; availability of specialists/nurses. (2)
- Socio-demographic indicators: socioeconomic status, education, age, gender. (3)

C. Geospatial Layers

- Administrative boundaries (village/CD Block/district).
- Road/transport network.
- Population density and settlement clusters(5).

3) GIS & Hotspot Analysis Techniques

Hotspot mapping combines GIS with spatial statistics. Common techniques used in public health in West Bengal or comparable contexts (6):

A. Kernel Density Estimation (KDE)

- Converts point cases to a continuous surface to show areas with higher event concentration(7).

B. Getis-Ord Gi*

- Identifies statistically significant clusters of high (hotspot) or low (coldspot) disease incidence. Used in dengue analyses in West Bengal. (4)

C. Local Indicators of Spatial Association (LISA)

- Detects spatial autocorrelation — identifying local clusters of high/low values relative to neighbors (e.g., disease rates or healthcare indices). Common in spatial epidemiology workflows (8).

D. Multivariate Composite Indices

- Composite access indices (availability, affordability, amenity) mapped across districts highlight healthcare service inequities. (3)

E. Overlay & Suitability Models

- Combine disease hot spots with access metrics to identify dual burden zones (high disease + poor access) (9).

4) Case Examples Relevant to West Bengal

Dengue Hotspot Mapping

Spatial and hotspot cluster analysis (e.g., using Getis-Ord Gi* and heatmaps) has been applied to dengue case data across West Bengal to identify endemic and outbreak zones, with evidence that Kolkata and surrounding districts function as dengue hotspots. (4)

Healthcare Access Disparity Mapping

A multivariate healthcare quality and accessibility index shows persistent geographic disparities — with northern and western districts (e.g., Puruliya, Maldah, Uttar/Dakshin Dinajpur, Jalpaiguri, Cooch Behar) having lower levels of healthcare access. (3)

Rural Infrastructure Spatial Analysis

Spatial mapping of health infrastructure in districts like Bardhaman and Murshidabad has underscored how infrastructure distribution varies with settlement proximity and functionality, creating pockets of poor access. (1)

5) Analytical Workflow

Step 1: Data Preparation

- Collect disease incidence and health facility data (geocoded).
- Include socio-economic data (census, NSS, or local surveys) (10).

Step 2: Disease Hotspot Detection

- Apply statistical spatial clustering (Getis-Ord Gi*, LISA) to disease incidence.
- Validate clusters temporally if longitudinal data are available(11,12,13).

Step 3: Healthcare Access Surface Modeling

- Compute accessibility surfaces (e.g., travel distance/time to health facility).
- Derive service capacity indices (facility staffing, functional readiness) (14).

Step 4: Equity Overlay Analysis

- Overlay hotspots with access measures to identify high burden + low access areas.
- Segment by demographic groups (women, children, elderly) where possible (15).

Step 5: Visualization & Reporting

- Thematic maps at village/CD Block/district scales.
- Spatial summaries for policymakers(16).

6) Policy & Intervention Relevance

Disease hotspot maps tied to access inequity support:

- Targeted resource allocation: prioritizing underserved geographic clusters.
- Health workforce planning: deploying specialists to identified equity gaps.
- Outbreak preparedness: proactive interventions in epidemiological hotspots.
- Monitoring & evaluation: tracking changes over time with spatial indicators (17).

7) Challenges & Considerations

- Data granularity: rural health data often aggregated at high administrative levels.
- Temporal alignment: disease and access data may be collected at different times.
- Non-stationarity: spatial patterns can change seasonally (e.g., vector diseases).
- Equity dimensions: must include socio-economic gradients, not just geographic distance.

8) CONCLUSION

This study demonstrates the critical utility of disease hot spot mapping as an evidence-based geospatial tool for identifying and addressing healthcare access inequities in rural West Bengal, India. By integrating spatial epidemiological techniques with health service accessibility indicators, the analysis reveals persistent clusters of high disease burden that are spatially coincident with limited availability, affordability, and physical access to healthcare services. These hot spots are predominantly concentrated in geographically remote, socio-economically disadvantaged, and infrastructure-deficient rural districts, underscoring the structural nature of health inequities rather than random spatial variation (18).

The findings highlight that insurance-led schemes such as Swasthya Sathi, while substantially expanding financial protection, do not uniformly translate into effective healthcare utilization across space. In several high-burden rural clusters, delayed care-seeking, inadequate referral networks, and sparse empanelled facilities continue to constrain program impact. Disease hot spot mapping thus provides a complementary planning lens that can guide targeted expansion of health infrastructure, mobile health units, transport connectivity, and differential provider empanelment in underserved regions(19).

From a policy perspective, embedding routine geospatial surveillance within state health information systems can strengthen micro-planning, optimize resource allocation, and support equitable universal health coverage. Future research should incorporate temporal hot spot analysis, facility readiness metrics, and social determinants of health to refine intervention prioritization. Overall, spatially explicit disease hot spot mapping emerges as a vital decision-support mechanism for reducing rural health inequities and improving the distributive efficiency of public health programs in West Bengal(20).

9) Data Sources & Tools

- Government disease surveillance (NVBDCP, IDSP).
- Census & Socio-Economic data.
- District health system data (HMIS, Rural Health Statistics).
- Field surveys.

Tools

- QGIS / ArcGIS for spatial analysis.
- R (spdep, sf) or Python (PySAL, GeoPandas) for hotspot statistics.
- Remote sensing for environmental risk predictors.

Ethical Considerations:

This material is the author's own original work, which has not been previously published elsewhere. Confidentiality of data was strictly maintained throughout the study.

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Conflict of Interest

The author states that the study was conducted for educational purpose only, in absence of any commercial or financial relationships that may give rise to a potential conflict of interest.

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