Geospatial Mapping and Susceptibility Modelling of Lassa fever Outbreaks in Resource-limited Settings: A case Study of Benue State, Nigeria

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Introduction

Lassa fever remains a public health threat in Nigeria, with increasing incidence in regions previously non-endemic. Despite ongoing surveillance efforts, geospatial heterogeneity in outbreak patterns complicates timely interventions. This study examined multi-dimensional risk factors influencing Lassa fever outbreaks, analyzed their geospatial dynamics, and developed a susceptibility model for targeted intervention.

Methods

A cross-sectional, mixed-methods geospatial epidemiological study was conducted across 277 wards in Benue State. Twenty-two indicators spanning environmental, socio-cultural, epidemiological, and health system domains were normalized and integrated using a Multi-Criteria Evaluation (MCE) framework. A linear weighted sum model was applied to compute a Susceptibility Index for each ward. Spatial clustering was analyzed using GIS tools. Model validity was assessed through correlation with historical Lassa fever case and death data, and Receiver Operating Characteristic (ROC) analysis was used to define optimal risk thresholds.

Results

The Susceptibility Index ranged from 0.14 to 0.65. ROC analysis identified 0.38 as the optimal threshold for distinguishing high-risk wards. Based on this, 51.3% of wards were classified as high-risk, 38.6% as moderate-risk (0.30–0.38), and 10.1% as low-risk (≤0.30). Spatial clustering revealed that LGAs such as Kwande, Oju, OBI, Buruku, and Gwer West had the highest concentrations of high-risk wards. Spearman correlation coefficients between the Susceptibility Index and historical cases and deaths were 0.13 and 0.09, respectively.

Conclusion

This study demonstrates the effectiveness of geospatial MCE modeling in identifying ward-level susceptibility to Lassa fever. The use of data-driven thresholds enhances model validity and supports targeted surveillance, resource allocation, and intervention planning. The approach offers a scalable framework for epidemic preparedness in other endemic regions.