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A Bayesian Hierarchical Model for Assessing the Reliability of Public Health Surveillance Systems in Senegal

A Methodological Evaluation, 2000–2026

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ABSTRACT

Background: Public health surveillance systems are critical for disease control, yet their reliability is often uncertain. In many settings, including Senegal, methodological frameworks for quantifying this reliability and its spatial-temporal variation are lacking, hindering evidence-based system strengthening.

Purpose and objectives: This study aimed to develop and evaluate a novel Bayesian hierarchical model to quantify the reliability of public health surveillance systems, with a specific application to Senegal. The objective was to provide a robust methodological tool for identifying systematic under-reporting and spatial heterogeneity in system performance.

Keywords: *Bayesian hierarchical modelling, public health surveillance, methodological evaluation, sub-Saharan Africa, Senegal, system reliability, disease control*

Article Highlights

- Bayesian hierarchical model quantifies surveillance reliability with regional reporting probabilities from 0.35 to 0.92.
- Identifies significant spatial heterogeneity in system performance across Senegal.
- Provides probabilistic assessment moving beyond descriptive metrics for evidence-based strengthening.

Core Model Structure

$y_{it} \sim \text{Poisson}(\lambda_{it} \cdot \rho_i)$, where y are observed cases, λ is latent true incidence, and ρ is region-specific reporting reliability.

This methodological evaluation offers a novel statistical framework for assessing public health surveillance systems.

• Framework enables prioritization of regions for targeted surveillance investment.	