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

A Methodological Evaluation, 2000–2026

Wanjiku Mwangi[1], **Kamau Ochieng**[2], **Kipchumba Bett**[2]
Amina Hassan[3]

Department of Epidemiology, African Population and Health Research Center (APHRC) | Maseno University | Pwani University

Correspondence: wmwangi@outlook.com

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ABSTRACT

Background: Public health surveillance systems are critical for disease control, yet their reliability in resource-limited settings is often uncertain. Methodological evaluations of these systems are required to quantify their performance and guide improvements.

Purpose and objectives: This study aimed to develop and apply a novel Bayesian hierarchical model to evaluate the reliability of national public health surveillance systems, using Kenya as a case study. The objective was to quantify system completeness and timeliness while accounting for spatial and temporal heterogeneity.

Keywords: *public health surveillance, Kenya, Bayesian hierarchical model, methodological evaluation, system reliability, sub-Saharan Africa*

Article Highlights

- Substantial spatial variation in surveillance reliability identified across districts.
- National annual reporting completeness estimated between 0.58 and 0.72.
- Temporal random effects show declining reliability during health system strain.
- Model provides framework to quantify uncertainty in surveillance data.

Core Methodological Framework

Bayesian hierarchical model with district and temporal random effects: $\text{logit}(p_{it}) = \alpha + \beta X_{it} + u_i + v_t$, estimated via MCMC simulation.

This methodological evaluation quantifies surveillance system reliability while accounting for spatial and temporal heterogeneity.