



A Bayesian Hierarchical Model for the Methodological Evaluation and Yield Optimisation of Public Health Surveillance Systems in Kenya: A Research Protocol (2000–2026)

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ABSTRACT

Public health surveillance systems in Kenya are critical for disease control but their methodological evaluation has been limited, often relying on descriptive statistics that fail to quantify uncertainty or integrate heterogeneous data sources for yield optimisation. This protocol details the development and application of a novel Bayesian hierarchical model to methodologically evaluate surveillance system performance and identify evidence-based strategies for optimising case detection yield. We will analyse longitudinal, district-level surveillance data. The core model is $y\{it\} \sim \text{Poisson}(\lambda\{it\})$, with $\log(\lambda\{it\}) = \alpha + \beta X\{it\} + u_i + v_t + \varepsilon\{it\}$, where u_i and v_t are structured spatial and temporal random effects. Model parameters will be estimated using Hamiltonian Monte Carlo, with posterior credible intervals used for inference on yield improvements attributable to specific interventions. As this is a protocol, no empirical findings are presented. The anticipated analysis will quantify, for instance, the posterior probability that integrating community health worker reports increases yield by a specified proportion, providing a probabilistic measure of intervention efficacy. The proposed model provides a rigorous, probabilistic framework for the methodological evaluation of surveillance systems, moving beyond point estimates to full

uncertainty quantification. Future surveillance evaluations should adopt Bayesian hierarchical modelling to inform targeted resource allocation. Policymakers should use the probabilistic outputs for risk-aware decision-making in system strengthening. Bayesian hierarchical model, surveillance evaluation, yield optimisation, public health, Kenya, uncertainty quantification This protocol introduces a novel application of Bayesian hierarchical modelling for the methodological evaluation of public health surveillance, providing a new tool for quantifying uncertainty in yield improvements and optimising detection strategies.

Keywords: *Bayesian hierarchical modelling, public health surveillance, health systems evaluation, sub-Saharan Africa, Kenya, yield optimisation, methodological framework*

Article Highlights

- Novel application of Bayesian hierarchical modelling for surveillance system evaluation.
- Quantifies uncertainty in yield improvements via posterior credible intervals.
- Integrates spatial and temporal random effects for heterogeneous district-level data.
- Provides probabilistic framework for risk-aware resource allocation decisions.

Core Methodological Contribution

A Poisson model with structured spatial (u_i) and temporal (v_t) random effects, estimated via Hamiltonian Monte Carlo, to probabilistically evaluate intervention impact on case detection yield.

This is a protocol paper; empirical findings from the 2000–2026 analysis are forthcoming.

ABSTRACT-ONLY PUBLICATION

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