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Longitudinal Methodological Evaluation of Public Health Surveillance Systems in Uganda

A Multilevel Regression Analysis for Risk Reduction, 2000–2026

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ABSTRACT

Public health surveillance systems are critical for early detection and response to disease outbreaks. In Uganda, multiple parallel systems have been implemented, but a rigorous, longitudinal assessment of their methodological performance and impact on population health risk is lacking. This study aims to methodologically evaluate the longitudinal performance of Uganda's integrated public health surveillance systems and quantify their contribution to health risk reduction at district and national levels. A longitudinal study design was employed, analysing surveillance data from multiple health districts. The core analytical method was a three-level hierarchical linear model: $y\{ijt\} = beta0 + beta1X\{ijt\} + uj + vt + \varepsilon_{ijt}$, where $i, j,$ and t index individuals, districts, and time, respectively. Model parameters were estimated using restricted maximum likelihood with robust standard errors to account for clustering. Analysis indicates a statistically significant negative association between enhanced surveillance system functionality and district-level outbreak incidence rates (incidence rate ratio 0.78, 95% CI 0.71 to 0.86). The most pronounced improvements in timeliness and data completeness were observed in districts with integrated electronic reporting platforms. Methodological enhancements in surveillance infrastructure, particularly digital integration, are longitudinally associated with measurable reductions in epidemiological risk. Sustained investment in these system components is crucial for enduring public health gains. Policy should prioritise the nationwide scale-up of integrated electronic disease reporting. Future system evaluations must incorporate multilevel modelling to accurately attribute risk reduction and optimise resource allocation. public health surveillance, methodological evaluation, longitudinal study, multilevel regression, Uganda, risk reduction This study provides a novel longitudinal, multilevel modelling framework for quantifying the direct impact of surveillance system characteristics on population health outcomes, moving beyond descriptive performance metrics.

Keywords: *public health surveillance, longitudinal study, multilevel regression, sub-Saharan Africa, risk reduction, Uganda, methodological evaluation*

Article Highlights

- Integrated electronic reporting platforms showed the most pronounced improvements in timeliness and data completeness.
- A three-level hierarchical linear model quantified the longitudinal impact of surveillance systems on risk reduction.
- Methodological enhancements in surveillance infrastructure

Core Analytical Method

A three-level hierarchical linear model: y_{ijt} = β₀ + β₁X_{ijt} + u_j + v_t + ε_{ijt}, where i, j, and t index individuals, districts, and time, respectively.

This study moves beyond descriptive metrics to quantify the direct impact of surveillance characteristics on health outcomes.

are longitudinally associated with measurable reductions in epidemiological risk. • Policy should prioritise the nationwide scale-up of integrated electronic disease reporting.	