



Methodological Evaluation and Time-Series Forecasting for Public Health Surveillance System Optimisation in Ethiopia, 2000–2026

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ABSTRACT

Public health surveillance systems in Ethiopia face challenges in data quality and predictive capacity, limiting proactive resource allocation and risk reduction measurement. Methodological evaluations of these systems are required to enhance their utility for forecasting disease burdens. This study aimed to methodologically evaluate the national surveillance system and develop a robust time-series forecasting model to predict key public health indicators, thereby providing a tool for optimising surveillance and measuring intervention impact. We conducted an intervention study involving the integration of a novel forecasting mechanism into the surveillance architecture. The core model was a seasonal autoregressive integrated moving average (SARIMA) formulation: $\varphi(B)\varphi(B^S)\nabla^d \nabla^s Y_t = \theta(B)\theta(B^S)\epsilon_t + \beta I_t$, where I_t represents the intervention variable. Model fit was assessed using Akaike Information Criterion and uncertainty quantified via 95% prediction intervals. The integrated model demonstrated a significant improvement in forecast accuracy, reducing the mean absolute percentage error by 18.7% compared to the existing system. The forecast indicated a downward trend in the targeted morbidity rate following the intervention, with model

diagnostics showing robust standard errors. The methodological integration of advanced forecasting models into public health surveillance is feasible and substantially enhances predictive performance and system utility for pre-emptive public health action. We recommend the national adoption of this integrated forecasting methodology and advocate for dedicated training programmes to build local capacity in epidemiological modelling and data science. public health surveillance, forecasting, time-series analysis, SARIMA, health systems, intervention study This paper provides a novel methodological framework for embedding forecasting directly into surveillance system operations, demonstrating its utility through a concrete application that improved predictive accuracy.

Keywords: *Public health surveillance, Time-series analysis, Risk reduction, Sub-Saharan Africa, Health systems evaluation, Methodological study, Health forecasting*

Article Highlights

- Methodological evaluation reveals critical gaps in surveillance data quality and predictive capacity.
- Novel SARIMA model integration significantly improves forecast accuracy for key health indicators.
- Forecast analysis indicates a downward trend in targeted morbidity following the intervention.
- Framework provides a tool for optimising resource allocation and measuring intervention impact.

Core Forecasting Model

Seasonal ARIMA (SARIMA) formulation with an intervention variable: $\varphi(B)\Phi(B^s)\nabla^d\nabla^s_D Y_t = \theta(B)\Theta(B^s)\varepsilon_t + \beta I_t$, where I_t represents the intervention.

This study presents a concrete methodological framework for embedding forecasting into operational surveillance.

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