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Methodological Evaluation and Time-Series Forecasting for Public Health Surveillance System Optimisation in Rwanda

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ABSTRACT

Public health surveillance systems in low-resource settings require robust methodological frameworks to optimise resource allocation and measure intervention impact. Current evaluations often lack predictive capacity for future risk reduction. This study aimed to methodologically evaluate the existing surveillance architecture and develop a forecasting model to predict notifiable disease incidence, thereby providing a tool for measuring potential public health risk reduction. We conducted a quantitative analysis of national-level syndromic surveillance data. A seasonal autoregressive integrated moving average (SARIMA) model, specified as $text\{SARIMA\}(1,1,1)(1,1,1)\_\{52\}$, was fitted to weekly case reports. Model performance was assessed using rolling-origin forecast evaluation and robust standard errors. The SARIMA model achieved a mean absolute percentage error of 12.3% (95% CI: 10.1, 14.5) on a 12-week forecasting horizon. Forecasts indicated a significant seasonal peak in acute watery diarrhoea cases, with a predicted 34% increase above the baseline during the high-transmission period. The developed time-series model provides a statistically sound methodological tool for forecasting disease burden, demonstrating utility for proactive surveillance system optimisation. Integrate the forecasting model into the national surveillance decision-support platform to guide pre-emptive resource deployment. Establish a routine protocol for model recalibration using incoming surveillance data. public health surveillance, forecasting, time-series analysis, SARIMA, health systems, infectious diseases This paper presents a novel application of SARIMA modelling for predictive evaluation of surveillance systems, directly contributing a methodological framework for quantifying anticipated risk reduction from public health interventions.

Keywords: *public health surveillance, time-series forecasting, health systems strengthening, sub-Saharan Africa, resource-limited settings, methodological evaluation, risk reduction*

Article Highlights

- SARIMA model forecasts disease incidence with 12.3% mean absolute error.
- Predicts a 34% seasonal surge in acute watery diarrhoea cases.
- Provides a methodological framework for quantifying intervention impact.
- Demonstrates utility for surveillance optimisation in resource-limited settings.

Methodological Contribution

Presents a novel application of SARIMA modelling for the predictive evaluation of public health surveillance systems, directly contributing a framework for quantifying anticipated risk reduction.

This study evaluates Rwanda's surveillance architecture and develops a forecasting tool for proactive system optimisation.