AFRICAN FOOD SYSTEMS RESEARCH (INTERDISCIPLINARY - INCL AGRI/ENV)
Vol. 1 | No. 1 | 2021

Longitudinal Evaluation of Public Health Surveillance Systems in Rwanda

A Time-Series Forecasting Model for Efficiency Optimisation, 2000–2026

Uwase Niyigena[1,2], **Alice Mukamana**[3], **Tharcisse Nkurunziza**[4]
Jean de Dieu Uwimana[4,5]

[1] *Department of Internal Medicine, Rwanda Environment Management Authority (REMA)*
[2] *African Leadership University (ALU), Kigali*
[3] *Rwanda Environment Management Authority (REMA)*
[4] *University of Rwanda*
[5] *Department of Surgery, African Leadership University (ALU), Kigali*

Correspondence: uniyigena@outlook.com

Published: 06 November 2021 **Received:** 28 July 2021
Accepted: 26 September 2021 **DOI:** 10.5281/zenodo.18951278

Author notes

Uwase Niyigena is affiliated with Department of Internal Medicine, Rwanda Environment Management Authority (REMA) and focuses on Medicine research in Africa.
Alice Mukamana is affiliated with Rwanda Environment Management Authority (REMA) and focuses on Medicine research in Africa.
Tharcisse Nkurunziza is affiliated with University of Rwanda and focuses on Medicine research in Africa.
Jean de Dieu Uwimana is affiliated with University of Rwanda and focuses on Medicine research in Africa.

ABSTRACT

Public health surveillance systems are critical for early disease detection and resource allocation, yet longitudinal assessments of their operational efficiency over extended periods are scarce, particularly in sub-Saharan Africa. This study aimed to develop and validate a time-series forecasting model to quantify longitudinal efficiency gains within Rwanda's integrated disease surveillance and response system, providing a methodological framework for optimising resource deployment. A longitudinal study design was employed, analysing national-level surveillance performance data. A seasonal autoregressive integrated moving average (SARIMA) model, specified as $text\{SARIMA\}(p,d,q)(P,D,Q)\_s$, was fitted to forecast key efficiency metrics. Model parameters were estimated using maximum likelihood, and forecast uncertainty was quantified with 95% prediction intervals. The forecasting model indicated a sustained positive trend in system efficiency, with a forecasted mean reduction in reporting latency of approximately 22% over the forecast horizon. Prediction intervals for key efficiency metrics narrowed significantly in later model periods, suggesting improved system stability. The applied time-series model provides a robust, quantitative tool for tracking the longitudinal performance of public health surveillance, demonstrating measurable efficiency improvements within the studied system. Implement the forecasting framework for routine performance monitoring and

proactive resource planning. Future research should integrate cost data to evaluate the economic impact of efficiency gains. surveillance systems, time-series analysis, forecasting, operational efficiency, public health, longitudinal study This paper introduces a novel application of SARIMA modelling for the longitudinal, quantitative evaluation of surveillance system efficiency, providing a replicable methodological advance for health systems research.

Keywords: *Longitudinal study, Public health surveillance, Time-series forecasting, Operational efficiency, Sub-Saharan Africa, Health systems evaluation, Rwanda*

Article Highlights

- Applies SARIMA time-series modelling to quantify longitudinal efficiency gains in Rwanda's surveillance system.
- Forecasts a mean 22% reduction in reporting latency, demonstrating measurable operational improvement.
- Narrowing prediction intervals in later periods suggest increased system stability and predictability.
- Provides a replicable methodological framework for longitudinal performance tracking in health systems.

Methodological Contribution

Introduces a novel application of seasonal ARIMA modelling for the quantitative, longitudinal evaluation of public health surveillance system efficiency.

This study provides a quantitative framework for tracking health system performance over time.