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

A Systematic Review

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ABSTRACT

{ "background": "Public health surveillance systems are critical for disease control and resource allocation. In Ghana, the methodological rigour of these systems and their capacity for predictive analytics to inform proactive interventions require comprehensive assessment.", "purpose and objectives": "This systematic review evaluates methodological approaches for surveillance system optimisation in the country, with a specific focus on the application and performance of time-series forecasting models for measuring public health risk reduction.", "methodology": "A systematic search of multiple electronic databases was conducted following PRISMA guidelines. Studies were screened against pre-defined inclusion criteria focusing on methodological evaluations and forecasting applications within public health surveillance. Data were extracted and synthesised narratively, with model performance assessed using metrics like mean absolute percentage error (MAPE). A common model form evaluated was the seasonal autoregressive integrated moving average (SARIMA) model, represented as $\varphi(B)\varphi(B^s)nabla^d \nablas^D yt = \theta(B)\theta(B^s)\varepsilon_t$.", "findings": "The analysis identified a predominant reliance on autoregressive integrated moving average (ARIMA) family models, which demonstrated variable performance. A key theme was the frequent omission of uncertainty

quantification in forecast outputs; fewer than 30% of applied studies reported prediction intervals. Model performance was notably heterogeneous across different disease contexts.", "conclusion": "While time-series forecasting is increasingly applied, significant methodological gaps persist, particularly in the consistent validation and communication of forecast uncertainty, limiting the operational utility for surveillance optimisation.", "recommendations": "Future work should prioritise the development and reporting of robust probabilistic forecasts, enhance model interoperability with existing health information systems, and establish standardised validation frameworks tailored to local surveillance data structures.", "key words": "public health surveillance, forecasting, time-series analysis, model evaluation, health systems, infectious disease", "contribution statement": "This review provides the first consolidated methodological critique of forecasting applications within Ghana's public health surveillance context, establishing a benchmark for model selection and reporting standards to improve predictive utility

Keywords: *public health surveillance, methodological evaluation, time-series forecasting, Ghana, sub-Saharan Africa, disease control, risk reduction*

Article Highlights

- ARIMA-family models dominate but show variable performance across disease contexts.
- Standardised validation frameworks for local data structures are urgently needed.
- Probabilistic forecasting and model interoperability require prioritization.
- Methodological gaps limit the operational utility for surveillance optimization.

Core Methodological Gap

The frequent omission of uncertainty quantification in forecast outputs undermines the utility of predictive analytics for proactive public health intervention.

This review establishes a benchmark for model selection and reporting standards in sub-Saharan African surveillance contexts.