



A Time-Series Forecasting Model for Maternal Care Systems

A Methodological Evaluation of Clinical Outcomes in Rwanda (2000–2026)

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ABSTRACT

{ "background": "Maternal healthcare systems in sub-Saharan Africa require robust, data-driven tools for strategic planning. Existing evaluations often rely on retrospective analyses, lacking predictive capacity for future clinical outcomes under varying resource scenarios.", "purpose and objectives": "This case study aims to methodologically evaluate the application of a time-series forecasting model to predict key maternal clinical outcomes within a national healthcare system, assessing its utility for facility-level resource planning.", "methodology": "We developed and applied a Seasonal AutoRegressive Integrated Moving Average with exogenous factors (SARIMAX) model, formalised as $\varphi(B)\varphi(B^s)\nabla^d\nabla^D yt = \theta(B)\theta(B^s)\epsilon_t + \beta Xt$, to historical facility-level data. The model incorporated exogenous variables including staffing ratios and drug supply metrics. Forecast accuracy was evaluated using rolling-origin cross-validation and 95% prediction intervals.", "findings": "The model demonstrated strong predictive accuracy for facility-level maternal mortality ratios, with a mean absolute percentage error of 8.7% in the validation period. Forecasts indicated a persistent, albeit decelerating, downward trend in the target ratio over the forecast horizon, contingent on the maintenance of current staffing inputs. Prediction intervals widened notably under simulated budget constraint scenarios.", "conclusion": "The SARIMAX framework provides a statistically robust methodological tool for forecasting clinical outcomes, offering health system managers a quantifiable basis for anticipatory decision-making.", "recommendations": "Integrate forecasting models into national health management information systems for routine outcome projection. Allocate training resources for analysts within health ministries to build in-house competency in time-series analysis.", "key words":

"health systems forecasting, maternal health, time-series analysis, SARIMAX, clinical outcomes, resource planning", "contribution statement": "This study provides a novel methodological application of a SARIMAX model to forecast facility-specific maternal clinical outcomes, demonstrating its operational value for proactive health system governance in a resource

Keywords: *Maternal healthcare, Time-series analysis, Clinical outcomes, Sub-Saharan Africa, Health systems evaluation, Forecasting model, Rwanda*

Article Highlights

- SARIMAX model achieved 8.7% mean absolute error in validation
- Forecasts show decelerating downward trend in maternal mortality
- Prediction intervals widen significantly under budget constraints
- Model incorporates staffing ratios and drug supply as key variables

Methodological Framework

SARIMAX model with exogenous variables including staffing ratios and drug supply metrics, evaluated using rolling-origin cross-validation.

This study demonstrates the operational value of forecasting models for proactive health system governance.

ABSTRACT-ONLY PUBLICATION

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