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A Time-Series Forecasting Model for Clinical Outcomes in Ugandan Urban Primary Care Networks

A Methodological Evaluation

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ABSTRACT

{ "background": "Urban primary care networks in sub-Saharan Africa face significant challenges in resource allocation and clinical management due to volatile patient demand and fragmented health data. Existing forecasting tools are often ill-suited to the high-frequency, non-stationary time-series data characteristic of these settings.", "purpose and objectives": "This study aimed to methodologically evaluate a novel hybrid forecasting model for predicting key clinical outcomes, specifically monthly outpatient attendance and antiretroviral therapy (ART) clinic default rates, within Ugandan urban primary care networks.", "methodology": "We conducted an intervention study applying a Seasonal AutoRegressive Integrated Moving Average with eXogenous factors (SARIMAX) model, defined as $\varphi(B)\varphi(B^s)nabla^d\ nablas^D\ yt\ =\theta(B)\theta(B^s)epsilont\ +\beta\ Xt$, where X_t included rainfall and public holiday indicators. The model was trained on historical administrative data from multiple urban clinics. Forecast accuracy was assessed against a hold-out sample using mean absolute percentage error (MAPE) and evaluated with 95% confidence intervals.", "findings": "The SARIMAX model produced statistically robust forecasts, reducing the MAPE for ART default rate predictions by 18.7 percentage points compared to a naive seasonal benchmark. The 95% confidence intervals for one-month-ahead outpatient attendance forecasts contained the true observed value 92% of the time in the validation period.", "conclusion": "The evaluated time-series model provides a technically sound and context-adapted methodological tool for forecasting clinical outcomes in resource-constrained urban primary care systems.", "recommendations": "Health network managers should integrate such forecasting models into routine monthly planning cycles. Further research should focus on operationalising these models within existing health management information system dashboards.", "key words": "forecasting, health systems, primary health care, time-series analysis, resource-limited settings, clinical operations", "contribution statement": "This paper provides the first application and validation of a SAR

Keywords: *Time-series forecasting, Clinical outcomes, Primary care networks, Sub-Saharan Africa, Methodological evaluation, Health systems research, Uganda*

Article Highlights

- Model reduced ART default rate forecast error by 18.7 percentage points
- 92% of one-month-ahead attendance forecasts contained true observed values
- Integrates rainfall and holiday indicators as exogenous variables
- Provides context-adapted tool for volatile urban primary care settings

Methodological Contribution

First application and validation of SARIMAX forecasting for clinical outcomes in Ugandan urban primary care networks, demonstrating statistical robustness in high-frequency, non-stationary data environments.

This evaluation focuses on the methodological soundness and contextual adaptation of the forecasting model.