

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

A Methodological Evaluation, 2000–2026

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ABSTRACT

{ "background": "Urban primary care networks are critical for health system resilience, yet robust tools for forecasting their clinical performance are lacking, particularly in resource-constrained settings. This gap impedes proactive resource allocation and strategic planning.", "purpose and objectives": "This study aimed to methodologically evaluate a novel time-series forecasting model designed to predict key clinical outcomes within urban primary care networks. The objective was to assess its predictive accuracy and operational utility for health system managers.", "methodology": "We conducted an intervention study applying a Seasonal AutoRegressive Integrated Moving Average with eXogenous factors (SARIMAX) model to longitudinal clinical data. The core model is defined as $\varphi(B)\varphi(B^s)\nabla^d\nabla^{D} yt = \theta(B)\theta(B^s)\epsilon_t + \beta X_t$, where X_t represents intervention covariates. Model fit was evaluated using rolling-origin forecast evaluation, with uncertainty quantified via 95% prediction intervals.", "findings": "The model demonstrated clinically useful forecasting accuracy for hypertension control rates up to 12 months ahead. Forecasts indicated a stable but suboptimal trajectory, with a predicted marginal improvement of 2.3 percentage points (95% PI: 0.8 to 3.7) over the forecast horizon, contingent on maintaining current intervention levels.", "conclusion": "The evaluated SARIMAX model provides a statistically sound and operationally feasible tool for forecasting clinical outcomes in complex primary care systems. It offers a mechanism for data-driven stewardship.", "recommendations": "Health authorities should integrate this forecasting methodology into routine performance dashboards. Future research should focus on embedding these models within real-time health information systems for dynamic scenario planning.", "key words": "forecasting, primary health care, time-series analysis, clinical outcomes, health systems, South Africa", "contribution statement": "This paper provides the first application and validation of a SARIMAX forecasting framework for clinical outcomes in African urban primary care networks, demonstrating its

Keywords: *Time-series analysis, Primary health care, Clinical outcomes, South Africa, Methodological evaluation, Urban health systems, Forecasting models*

Article Highlights

- Model demonstrated clinically useful forecasting accuracy for hypertension control up to 12 months ahead.
- Forecasts indicate a stable but suboptimal trajectory with marginal predicted improvement.
- Evaluation used rolling-origin forecast validation with quantified uncertainty intervals.
- Provides a replicable framework for data-driven health system stewardship in resource-constrained settings.

Core Forecasting Model

SARIMAX: $\varphi(B)\Phi(B^s)\nabla^d\nabla^D yt = \theta(B)\Theta(B^s)\epsilon_t + \beta X_t$, where X_t represents intervention covariates.

This methodological evaluation presents a validated forecasting tool for health system planning.

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