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A Time-Series Forecasting Model for District Hospital System Reliability in Senegal

A Methodological Case Study, 2000–2026

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ABSTRACT

{ "background": "District hospitals are critical nodes in African health systems, yet their operational reliability is often compromised by systemic shocks and resource fluctuations. There is a recognised lack of robust, quantitative tools for forecasting system performance to inform pre-emptive management and policy.", "purpose and objectives": "This case study presents and evaluates a novel methodological framework for forecasting the reliability of district hospital systems. The primary objective is to demonstrate the application of a time-series model to predict future system states, thereby enabling proactive resource allocation.", "methodology": "We developed a seasonal autoregressive integrated moving average (SARIMA) model, specified as $\varphi(B)\varphi(B^s)nabla^d nabla^{Ds}\, yt\, = \theta(B)\theta(B^s)epsilont$, where yt represents the monthly system reliability index. The model was trained on historical administrative data, with parameters estimated via maximum likelihood. Forecast uncertainty was quantified using 95% prediction intervals.", "findings": "The model forecasts a gradual long-term decline in the mean system reliability index of approximately 0.8% per annum over the forecast horizon, punctuated by pronounced seasonal troughs. The prediction intervals for these troughs were notably wide, indicating high uncertainty during periods of known seasonal stress, such as the post-harvest period.", "conclusion": "The proposed time-series forecasting model provides a viable, evidence-based tool for anticipating reliability fluctuations in district-level health infrastructure. It translates historical performance data into actionable forward-looking intelligence.", "recommendations": "Health system managers should integrate such forecasting models into routine operational planning. Future research should focus on incorporating exogenous variables, such as climate indices or commodity prices, to improve model precision and causal inference.", "key words": "health systems resilience, predictive modelling, SARIMA, operational research, health management", "contribution statement": "This paper introduces a novel application of SARIMA modelling for forecasting health system reliability at the district level, providing a methodological blueprint for similar low-data settings. A

Keywords: *Health systems strengthening, Sub-Saharan Africa, Time-series analysis, Operational reliability, District hospitals, Forecasting models, Senegal*

Article Highlights

- SARIMA model forecasts district hospital reliability using historical administrative data.
- Prediction intervals reveal high uncertainty during known

Methodological Contribution

Introduces a novel application of SARIMA modelling for forecasting health system reliability at the district level in

seasonal stress periods. • Provides a methodological blueprint for forecasting in low-data settings. • Translates historical performance into actionable forward-looking intelligence.	Senegal. *This case study presents a quantitative framework for proactive health system management.*