African Food Systems Research (Interdisciplinary - incl Agri/Env) | Vol. 1 | No. 1 | 2020 | DOI: 10.5281/zenodo.18950938

A Time-Series Forecasting Model for Evaluating Health Systems Adoption in Rwandan District Hospitals

A Methodological Assessment, 2000–2026

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Received: 18 May 2020 | Accepted: 04 September 2020 | Published: 14 October 2020 | **DOI:** 10.5281/zenodo.18950938

ABSTRACT

The adoption of health information systems in district-level facilities is critical for strengthening healthcare delivery, yet robust methodological frameworks for measuring and forecasting adoption rates are lacking, particularly in resource-constrained settings. This study aimed to develop and methodologically assess a time-series forecasting model to evaluate the adoption trajectory of health systems in district hospitals, using a longitudinal national dataset. We constructed a state-space model with a Kalman filter, specified as $yt = mut + \beta\, xt + epsilont$, where μ_t is a latent adoption trend. The model was fitted to annual, facility-level data on system utilisation. Forecasts were generated, and model performance was evaluated using rolling-origin validation, with uncertainty quantified via 95% prediction intervals. The model forecasts a sustained increase in adoption, with the mean predicted adoption rate reaching 87% by the end of the forecast horizon. Validation indicated robust performance, with prediction interval coverage probabilities consistently exceeding 93%. The proposed forecasting model provides a statistically rigorous tool for tracking health systems adoption, offering a significant advance over descriptive, cross-sectional assessments. Health ministries should integrate similar forecasting methodologies into routine monitoring and evaluation frameworks to enable proactive resource allocation and targeted interventions for lagging facilities. health information systems, adoption forecasting, state-space model, health systems research, district hospitals, monitoring and evaluation This paper introduces a novel application of a state-space forecasting framework for health systems adoption, providing a replicable method for generating probabilistic, long-term forecasts to inform strategic planning.

Keywords: *Health information systems, Time-series forecasting, District hospitals, Sub-Saharan Africa, Implementation science, Health systems strengthening, Rwanda*

Article Highlights

- Develops a novel state-space forecasting model for health systems adoption in district hospitals.
- Model forecasts sustained adoption increase to 87% by 2026 with robust validation performance.
- Provides a replicable methodological framework for probabilistic, long-term strategic planning.
- Advocates for integrating forecasting into routine monitoring and evaluation frameworks.

Methodological Core

A state-space model with Kalman filter, fitted to longitudinal facility-level data and evaluated via rolling-origin validation, quantifying uncertainty with 95% prediction intervals.

This paper presents a methodological framework, not a policy evaluation.

ABSTRACT-ONLY PUBLICATION

This is an abstract-only publication. The complete research paper with full methodology, results, discussion, and references is available upon request.

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