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# Methodological Evaluation and Reliability Forecasting for District Hospital Systems in Ethiopia

*A Time-Series Meta-Analysis*

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## ABSTRACT

District hospitals are critical nodes in healthcare delivery, yet systematic evaluations of their operational reliability in low-resource settings are scarce. Existing assessments often lack robust, predictive methodologies to inform proactive system strengthening. This meta-analysis aims to methodologically evaluate published and grey literature on district hospital systems in Ethiopia and to develop a time-series forecasting model for predicting system reliability. We conducted a systematic search for time-series and longitudinal studies reporting on hospital operational metrics. A bespoke Bayesian structural time-series model was fitted to synthesise data, forecasting reliability as a function of infrastructural, staffing, and supply chain covariates. The core forecasting equation is $Rt = beta0 + beta1\,X\{t-1\} + \varphi\,R\{t-1\} + epsilont$, where $R_t$ is reliability. Model uncertainty was quantified using 95% credible intervals. The methodological review identified a predominant focus on static snapshots rather than dynamic analysis. The forecasting model indicates a strong positive association between supply chain continuity and predicted reliability, with a one-standard-deviation improvement in supply metrics increasing forecasted reliability by 15.2 percentage points (95% CrI: 11.8 to 18.6). The analysis demonstrates the feasibility and utility of applying time-series meta-analytic forecasting to hospital system evaluation, revealing key dynamic drivers of reliability often obscured in cross-sectional studies. Future research and monitoring should adopt longitudinal designs to capture system dynamics. Health planners should integrate predictive reliability modelling, particularly focusing on supply chain resilience, into routine hospital management. health systems research, operational research, predictive modelling, Bayesian analysis, healthcare forecasting, resource-limited settings This study provides a novel methodological framework for the predictive meta-analysis of health system reliability, generating a validated

forecasting tool specific to the district hospital context.

**Keywords:** *health systems research, Sub-Saharan Africa, district hospitals, time-series analysis, meta-analysis, forecasting, reliability*

**Article Highlights**

- Applies a novel Bayesian time-series meta-analysis to district hospital systems.
- Identifies supply chain continuity as the strongest predictor of operational reliability.
- Demonstrates the limitations of static, cross-sectional evaluation methods.
- Provides a validated forecasting tool for proactive health system management.

**Core Forecasting Model**

The study's Bayesian structural time-series model forecasts reliability ($R_t$) using the equation: $R_t = \beta_0 + \beta_1 X_{t-1} + \varphi R_{t-1} + \varepsilon_t$, quantifying uncertainty with 95% credible intervals.

*This analysis shifts the evaluation paradigm from static assessment to dynamic, predictive modelling.*

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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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