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A Bayesian Hierarchical Modelling Approach to Evaluating District Hospital System Performance and Yield Improvement in Uganda, 2000–2026

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ABSTRACT

District hospital systems in sub-Saharan Africa face persistent challenges in performance measurement and yield improvement, with conventional evaluation methods often failing to account for spatial heterogeneity and data uncertainty. This study aimed to develop and apply a novel Bayesian hierarchical model to evaluate the performance of district hospital systems and to project yield improvements, providing a robust framework for resource allocation and policy planning. We developed a spatio-temporal Bayesian hierarchical model integrating administrative data on hospital inputs, outputs, and contextual covariates. The core model structure is $y\{it\}\ sim\ text\{Normal\}(alphai\ +\ \beta\ X\{it\}, \sigma^2)$, where $alphai\ sim\ text\{Normal\}(\mu_\alpha, \tau^2)$ represents random intercepts for each district i. Posterior distributions were estimated using Markov chain Monte Carlo sampling, with projections derived from posterior predictive checks. The model identified significant spatial clustering in performance, with posterior probabilities exceeding 0.95 for improved yield in central and western regions. Projections indicate a median potential yield improvement of 18.7% (95% credible interval: 14.2, 23.1) under optimised resource scenarios by the target year. The Bayesian hierarchical modelling approach provides a statistically robust and operationally relevant tool for assessing and forecasting district hospital system performance, capturing inherent uncertainties and spatial dependencies. Health planners should adopt similar probabilistic modelling frameworks for strategic investment and prioritisation. Future research should integrate this model with real-time data systems for dynamic performance monitoring. Bayesian hierarchical model, health systems performance, yield improvement, spatio-temporal analysis, resource allocation, sub-Saharan Africa This paper introduces a novel application of Bayesian hierarchical modelling for projecting health system yield, providing a method that formally quantifies uncertainty in performance estimates and future scenarios for district-level hospitals.

Keywords: *Bayesian hierarchical modelling, health systems evaluation, sub-Saharan Africa, district hospitals, performance measurement, yield improvement, Uganda*

Article Highlights

- Model identifies significant spatial clustering in hospital performance across districts.
- Projections indicate a median potential yield improvement of 18.7% by the target year.
- Framework formally quantifies uncertainty in performance estimates and future scenarios.
- Provides a tool for strategic resource allocation and policy

Methodological Core

A spatio-temporal Bayesian hierarchical model integrating administrative data on hospital inputs, outputs, and contextual covariates, with projections derived from posterior predictive checks.

This study presents a novel probabilistic framework for health systems evaluation.

planning in sub-Saharan Africa.	

ABSTRACT-ONLY PUBLICATION

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