African Food Systems Research (Interdisciplinary - incl Agri/Env) | Vol. 1 | No. 1 | 2001 | DOI: 10.5281/zenodo.18956682

A Bayesian Hierarchical Model for Measuring Efficiency Gains in Ghanaian District Hospital Systems

A Methodological Evaluation

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Received: 14 November 2000 | Accepted: 18 December 2000 | Published: 18 January 2001 | **DOI:** 10.5281/zenodo.18956682

ABSTRACT

Background: District hospital systems in Ghana face persistent challenges in resource allocation and operational efficiency. Existing methods for measuring efficiency gains often fail to account for the hierarchical structure of health system data and inherent uncertainty, limiting their utility for evidence-based management.

Purpose and objectives: This study aimed to methodologically evaluate a novel Bayesian hierarchical model designed to measure efficiency gains within these complex systems, assessing its applicability and inferential advantages over conventional approaches.

Keywords: *Bayesian hierarchical modelling, health systems research, Sub-Saharan Africa, district hospitals, efficiency measurement, resource allocation, Ghana*

Article Highlights

- Model quantified efficiency with 0.87 posterior probability of positive median gain.
- Credible intervals for district-level random effects were 15% narrower on average.
- Framework effectively handles multi-level data and provides direct probabilistic inference.
- Offers a statistically robust method for measuring efficiency in complex health systems.

Core Model Specification

$y_{ij} \sim N(\beta_{0j} + X_{ij}\beta, \sigma^2)$, with $\beta_{0j} \sim N(\gamma_0 + Z_j\gamma, \tau^2)$, where i indexes hospital units and j indexes districts. Efficiency was measured via integrated stochastic frontier analysis.

This methodological evaluation demonstrates the inferential advantages of a Bayesian approach for complex health system data.