AFRICAN FOOD SYSTEMS RESEARCH (INTERDISCIPLINARY - INCL AGRI/ENV)
Vol. 1 | No. 1 | 2023

A Bayesian Hierarchical Modelling Framework for Evaluating Clinical Outcomes in Rwanda's Rural Health Clinic Systems

A Systematic Review

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Published: 11 December 2023 **Received:** 25 July 2023

Accepted: 21 November 2023 **DOI:** 10.5281/zenodo.18949938

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ABSTRACT

Background: Rwanda's rural health clinic systems are critical for delivering primary care, yet robust methodological frameworks for evaluating their clinical outcomes are underdeveloped. Existing approaches often lack the statistical rigour to handle the hierarchical, multi-source data characteristic of these settings.

Purpose and objectives: This systematic review aims to critically appraise the application of Bayesian hierarchical modelling (BHM) for evaluating clinical outcomes within Rwanda's rural clinic systems, assessing its methodological advantages, implementation challenges, and evidence of impact.

Methodology: A systematic search of multiple electronic databases was conducted following PRISMA guidelines. Studies were included if they employed a BHM to analyse clinical outcome data from rural Rwandan health facilities. Data were extracted on model specification, data sources, and inference methods. The core model form was $y\{ij\} \sim \text{Bernoulli}(p\{ij\}),\\; \text{logit}(p\{ij\}) = \alpha + \alpha\{j[i]\} + \beta X\{ij\}$, where $\alpha\{j\} \sim N(0,\sigma\{\alpha\}^2)$ represents clinic-level random effects.

Keywords: *Bayesian hierarchical modelling, clinical outcomes, rural health systems, Rwanda, sub-Saharan Africa, systematic review, primary healthcare*

Article Highlights

- Quantifies clinic-level heterogeneity with credible intervals for random effects
- Addresses sparse data challenges through strength borrowing across units
- Provides coherent framework for nested, multi-source clinical data
- Implementation constrained by technical capacity and data quality

Core Model Specification

The reviewed studies commonly employed: $y_{ij} \sim \text{Bernoulli}(p_{ij}), \; \text{logit}(p_{ij}) = \alpha + \alpha_{j[i]} + \beta X_{ij}$, with $\alpha_{j} \sim N(0, \sigma_{\alpha}^2)$ representing clinic-level random effects.

This review assesses methodological application rather than clinical efficacy.

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