

A Bayesian Hierarchical Modelling Approach to the Cost-Effectiveness of Community Health Centre Systems in Uganda

Grace Akello^{1,2}, Josephine Nakato^{2,3}, David Kato Mubiru^{4,5}

National Agricultural Research Organisation (NARO) | Uganda Christian University, Mukono | Department of Clinical Research, National Agricultural Research Organisation (NARO) | Kyambogo University, Kampala | Department of Epidemiology, National Agricultural Research Organisation (NARO)

Correspondence: gakello@hotmail.com

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ABSTRACT

Background: Community health centres are a cornerstone of primary healthcare delivery in many African nations, yet robust, data-driven evaluations of their cost-effectiveness remain scarce. Existing analyses often fail to adequately account for hierarchical data structures and the substantial uncertainty inherent in resource-limited settings.

Purpose and objectives: This study aimed to develop and apply a novel Bayesian hierarchical model to evaluate the cost-effectiveness of community health centre systems, using Uganda as a case study. The primary objective was to quantify the incremental cost per disability-adjusted life year (DALY) averted, while formally propagating uncertainty from multiple data levels.

Methodology: We conducted an intervention study analysing operational and health outcome data from a network of community health centres. The core methodological innovation is a Bayesian hierarchical model specified as: $\text{Cost} - \text{Effectiveness}_{ij} \sim \text{Normal}(\alpha_j + \beta X_{ij}, \sigma^2)$, $\alpha_j \sim \text{Normal}(\mu_\alpha, \tau_\alpha^{-1})$, where i indexes patients and j indexes centres. Parameters were estimated using Hamiltonian Monte Carlo, with cost-effectiveness acceptability curves derived from the posterior distributions.

Keywords: Bayesian hierarchical modelling, cost-effectiveness analysis, community health centres, sub-Saharan Africa, primary healthcare, Uganda, health systems evaluation

Article Highlights

- Median cost per DALY averted estimated at US\$ 42.50 with robust credible intervals.
- 92% probability system is cost-effective at a US\$ 100 per DALY willingness-to-pay.
- Substantial heterogeneity identified between health centres via random effects.
- Method provides coherent framework for multi-level uncertainty in resource-limited settings.

Methodological Innovation

A novel Bayesian hierarchical model formally propagates uncertainty from patient and centre levels, offering superior analytical rigor for health systems evaluation.

This analysis provides a statistically robust framework for evaluating primary healthcare investments in sub-Saharan Africa.

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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