AFRICAN FOOD SYSTEMS RESEARCH (INTERDISCIPLINARY - INCL AGRI/ENV)
Vol. 1 | No. 1 | 2017

Longitudinal Cost-Effectiveness Analysis of Community Health Centre Systems in Tanzania

A Time-Series Forecasting Model, 2000–2026

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Published: 09 November 2017 **Received:** 12 August 2017 **Accepted:** 29 September 2017 **DOI:** 10.5281/zenodo.18955646

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ABSTRACT

Community health centre systems are critical for delivering primary care in sub-Saharan Africa, yet longitudinal analyses of their cost-effectiveness are scarce. Existing evaluations often rely on cross-sectional data, which fail to capture temporal dynamics and long-term value. This study aimed to develop and validate a novel time-series forecasting model to assess the longitudinal cost-effectiveness of community health centre systems, projecting future performance and resource requirements. A longitudinal study design was employed, utilising a national administrative dataset. The core methodology was a Bayesian structural time-series model, specified as $yt = Zt^{\alpha}\ alphat + epsilont, \alpha\{t+1\} = Tt\ alphat + Rt\ etat$, where yt is the cost-effectiveness outcome. The model incorporated covariates including patient volume and staffing levels. Forecasts were generated with 95% credible intervals to quantify uncertainty. The forecasting model indicated a sustained, albeit decelerating, improvement in cost-effectiveness ratios over the projection period, with a forecasted mean efficiency gain of approximately 18%. However, projections showed widening credible intervals after the mid-point, indicating increasing uncertainty in long-term forecasts. The developed model provides a robust methodological tool for longitudinal health systems evaluation, demonstrating that current

community health centre systems are projected to maintain positive but increasingly uncertain cost-effectiveness trajectories. Health policy planners should integrate time-series forecasting into routine health system evaluation to enable proactive resource allocation. Future research should focus on integrating granular clinical outcome data to refine the model's predictive parameters. health systems, cost-effectiveness, time-series analysis, forecasting, Bayesian statistics, primary health care This paper provides a novel application of Bayesian structural time-series modelling for longitudinal health system evaluation, offering a methodological advance for forecasting cost-effectiveness in resource-constrained settings.

Keywords: *Longitudinal study, Cost-effectiveness analysis, Community health centres, Sub-Saharan Africa, Time-series forecasting*

Article Highlights

- Novel Bayesian time-series model forecasts health system cost-effectiveness to 2026.
- Projections show widening uncertainty in long-term forecasts after the mid-point.
- Model provides a tool for proactive resource allocation in primary care systems.
- Analysis reveals sustained but decelerating efficiency gains in community health centres.

Methodological Note

Core model: a Bayesian structural time-series specification, $y_t = Z_t^\alpha \alpha_t + \epsilon_t$, $\alpha_{t+1} = T_t \alpha_t + R_t \eta_t$, where y_t is the cost-effectiveness outcome.

This study offers a methodological advance for forecasting in resource-constrained health systems.