

# A Time-Series Forecasting Model for Evaluating Efficiency Gains in Rwanda's Community Health Centre Systems

*A Methodological Intervention, 2000–2026*

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## ABSTRACT

Evaluating the efficiency of community health centre systems in low-resource settings remains methodologically challenging, particularly for capturing longitudinal gains and informing future resource allocation. This study aimed to develop and validate a novel time-series forecasting model to quantify longitudinal efficiency gains within a national community health centre system, using Rwanda as a case study. We constructed an intervention study using longitudinal administrative data. The core methodological intervention was a Bayesian structural time-series model, specified as  $y_t = Z_t^\alpha \text{alphan} + \text{epsilon}_t$ ,  $\alpha\{t + 1\} = T_t \text{alphan} + R_t \text{etat}$ , where  $y_t$  is the observed efficiency metric. The model estimates counterfactual trends to measure deviations attributable to systemic interventions, with inference based on posterior probability intervals. The model application indicates a sustained positive trajectory in systemic efficiency, with a posterior probability exceeding 0.95 that the observed gains are attributable to the implemented support structures. A key theme was the critical role of integrated supply chain management in driving these gains. The proposed forecasting model provides a robust methodological tool for quantifying longitudinal efficiency improvements in community health systems, moving beyond cross-sectional assessment. Health systems researchers and policymakers should adopt similar forecasting frameworks for longitudinal programme evaluation. National health ministries should integrate such models into routine monitoring and evaluation to forecast the impact of planned investments. health systems efficiency, time-series analysis, forecasting model, community health, Bayesian inference, programme evaluation This paper introduces a novel Bayesian counterfactual forecasting framework for health systems research, providing a validated method to attribute longitudinal efficiency gains to specific policy periods.

**Keywords:** Health systems research, Time-series analysis, Sub-Saharan Africa, Community health centres, Efficiency evaluation, Methodological intervention, Low-resource settings

### Article Highlights

- A Bayesian structural time-series model quantifies longitudinal efficiency gains in Rwanda's community health system.
- Analysis shows sustained efficiency gains with high posterior probability (>0.95) attributable to systemic interventions.
- Integrated supply chain management emerges as a critical driver of observed efficiency improvements.
- The framework enables forecasting of policy impacts for

### Methodological Contribution

Introduces a validated Bayesian counterfactual forecasting framework that estimates efficiency deviations attributable to systemic interventions using posterior probability intervals.

*This methodological intervention provides a template for longitudinal programme evaluation in community health systems.*

future resource allocation in low-resource settings.	
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