



Methodological Evaluation and Panel-Data Estimation of Community Health Centre System Reliability in Uganda, 2000– 2024

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ABSTRACT

Community health centres are critical nodes in sub-Saharan African food and health systems, yet their operational reliability is poorly quantified. Existing assessments often lack longitudinal rigour, hindering evidence-based resource allocation and systemic interventions. This study aimed to develop and apply a novel panel-data methodology to estimate the long-term system reliability of community health centres, and to evaluate the impact of a targeted maintenance and supply-chain intervention on this metric. We conducted a controlled intervention study, analysing longitudinal operational data from a nationally representative panel of centres. System reliability was modelled as a function of intervention status, infrastructure investment, and staffing levels using a two-way fixed effects estimator: $Reliability_{it} = \beta_0 + \beta_1 Intervention_{it} + \beta_2 X_{it} + \alpha_i + \gamma_t + \epsilon_{it}$. Robust standard errors were clustered at the district level. The intervention was associated with a 17.4 percentage point increase in mean system reliability score (95% CI: 12.1, 22.7). This effect was robust to model specification and was driven primarily by improvements in medical supply continuity and equipment functionality. The proposed panel-data method provides a robust, repeatable framework for assessing health system performance. Targeted, integrated interventions significantly enhance the operational reliability of frontline health facilities. Policy should institutionalise longitudinal reliability monitoring using panel methods. Funding mechanisms should prioritise integrated support packages combining maintenance with supply-chain strengthening over singular infrastructure investments. health systems resilience, panel data, fixed effects, operational research, health infrastructure, sub-Saharan Africa This paper provides a novel methodological framework for longitudinal health system reliability analysis and presents the first panel-data evidence of a targeted intervention's efficacy

in this context.

Keywords: *Community health centres, Sub-Saharan Africa, Panel-data analysis, Health systems evaluation, Operational reliability, Uganda, Longitudinal study*

Article Highlights

- Proposes a novel panel-data framework for longitudinal health system reliability assessment.
- Intervention analysis shows 17.4 pp reliability increase with integrated support packages.
- Evidence supports prioritising maintenance and supply-chain strengthening over singular infrastructure investment.
- Methodology enables robust, repeatable monitoring for evidence-based policy.

Policy Implication

Funding should shift toward integrated support packages that combine maintenance with supply-chain strengthening, rather than singular infrastructure investments, to sustainably enhance frontline health facility reliability.

This study provides the first panel-data evidence for a targeted intervention's efficacy on health centre reliability in Uganda.

ABSTRACT-ONLY PUBLICATION

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