

Assessing District Hospital System Reliability in Rwanda

A Multilevel Regression Analysis of Methodological Interventions

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ABSTRACT

Background: District hospitals are critical nodes in healthcare delivery, yet robust methodologies for quantifying the reliability of their integrated systems—encompassing clinical, logistical, and administrative functions—are lacking. This methodological gap hinders evidence-based interventions to strengthen health system performance.

Purpose and objectives: This study aimed to develop and evaluate a novel methodological framework for assessing district hospital system reliability. The primary objective was to test the efficacy of specific analytical interventions, including multilevel modelling, in generating more precise and actionable reliability metrics.

Methodology: We conducted an intervention study across a nationally representative sample of district hospitals. System reliability was operationalised via a composite index derived from routine service data. The core methodological intervention was the application of a three-level hierarchical linear model: $y_{ijk} = \beta_0 + u_{0jk} + v_{0k} + \varepsilon_{ijk}$, where i , j , and k index observations, hospitals, and districts, respectively. Model robustness was assessed using cluster-robust standard errors.

Keywords: District hospitals, Sub-Saharan Africa, Health systems research, Multilevel modelling, Intervention study, System reliability, Rwanda

Article Highlights

- A three-level hierarchical model partitions variance across observations, hospitals, and districts.
- Hospital-level random effects showed significant heterogeneity, unmasking performance disparities.
- The framework identified pharmaceutical logistics as a primary driver of system unreliability.
- Methodology moves beyond descriptive averages to pinpoint specific leverage points for intervention.

Core Analytical Intervention

The study's central methodological innovation was applying a three-level hierarchical linear model: $y_{ijk} = \beta_0 + u_{0jk} + v_{0k} + \varepsilon_{ijk}$, where i , j , and k index observations, hospitals, and districts, respectively.

This study presents a novel framework for quantifying health system reliability with actionable precision.

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