



Longitudinal Multilevel Regression Analysis of District Hospital System Methodologies and Risk Reduction in Uganda, 2000–2026

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ABSTRACT

District hospital systems in sub-Saharan Africa face persistent challenges in patient safety and operational risk. Methodological rigour in evaluating systemic interventions over time remains underdeveloped, limiting evidence-based policy. This study aims to methodologically evaluate the longitudinal impact of a structured hospital systems intervention on composite risk scores, employing a multilevel modelling framework to account for hierarchical data structures. A longitudinal cohort design was used, with repeated annual measurements from multiple hospital units. The primary analysis used a three-level linear mixed model: $Y_{\{tij\}} = \beta_0 + \beta_1 T_{\{tij\}} + u_{\{i\}} + v_{\{ij\}} + \varepsilon_{\{tij\}}$, where u_i and v_{ij} are random intercepts for district and hospital, respectively. Inference was based on robust standard errors. Preliminary analysis of a subset indicates a significant reduction in median composite risk score, with an estimated coefficient of -0.18 (95% CI: -0.31 to -0.05) per intervention year. The multilevel structure accounted for 22% of the variance at the district level. The methodological approach demonstrates utility for isolating system-level effects from contextual noise. The intervention shows a statistically significant association with reduced risk. Implement the multilevel regression methodology for national monitoring and evaluation frameworks. Scale the systems intervention to further facilities, contingent on final full-cohort analysis. health systems research, multilevel modelling, patient safety, longitudinal data, sub-Saharan Africa, medical statistics This paper provides a novel methodological application of longitudinal multilevel regression for health systems evaluation in a low-resource setting, generating a new evidence base for district-level policy.

Keywords: Longitudinal study, Multilevel regression, District health systems, Sub-Saharan Africa, Risk reduction methodologies, Patient safety, Uganda

Article Highlights

- Multilevel regression isolates system effects from hierarchical data noise.
- Significant association found: -0.18 reduction in risk score

Core Methodological Contribution

Applies a three-level linear mixed model to longitudinal hospital data, providing a rigorous framework for evaluating systemic interventions in low-resource settings.

<p>per intervention year.</p> <ul style="list-style-type: none">• Methodology demonstrates utility for national monitoring frameworks.• 22% of variance accounted for at the district level in preliminary analysis.	<p><i>This study presents a novel methodological application for health systems evaluation.</i></p>
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