

# A Methodological Evaluation and Cost-Effectiveness Analysis of Public Health Surveillance Systems in Rwanda

*A Panel-Data Approach*

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## ABSTRACT

Public health surveillance is a cornerstone of effective disease control, yet rigorous methodological evaluations of its cost-effectiveness in low-resource settings are scarce. Existing analyses often lack longitudinal rigour and robust econometric techniques to account for unobserved heterogeneity. This study aims to provide a comprehensive methodological evaluation and cost-effectiveness analysis of Rwanda's integrated disease surveillance system, employing a panel-data approach to derive more reliable estimates of system performance and resource efficiency. We constructed a district-level panel dataset from administrative records. Cost-effectiveness was estimated using a two-way fixed effects model:  $Y_{it} = \beta_0 + \beta_1 \text{text}\{\log\}(\text{text}\{\text{Cost}\}_{it}) + \mu_i + \lambda_t + \varepsilon_{it}$ , where  $Y_{it}$  is a composite performance index for district  $i$  in period  $t$ . Robust standard errors were clustered at the district level. A 10% increase in surveillance expenditure was associated with a 3.2% improvement in the performance index (95% CI: 1.8% to 4.6%). The system demonstrated increasing returns to scale in densely populated districts, but marginal gains diminished significantly in remote regions. The surveillance system is cost-effective overall, but its efficiency is not uniform geographically. The panel-data methodology revealed substantial district-level heterogeneity that cross-sectional analyses obscure. Resource allocation should be tailored based on population density and remoteness. Methodologically, future evaluations should adopt longitudinal designs to control for unobserved confounders and improve causal inference. health surveillance, cost-effectiveness, panel data, econometric evaluation, health systems, Rwanda This study provides the first application of a district-level panel-data model to evaluate health surveillance cost-effectiveness in the region, introducing a novel composite performance index that integrates timeliness, completeness, and data quality.

**Keywords:** *public health surveillance, cost-effectiveness analysis, panel data, sub-Saharan Africa, health systems evaluation, Rwanda*

### Article Highlights

- Panel-data analysis reveals substantial district-level heterogeneity obscured by cross-sectional methods.
- Surveillance system shows increasing returns to scale in dense populations, but diminishing gains in remote areas.
- Introduces a novel composite performance index integrating timeliness, completeness, and data quality.

### Methodological Contribution

First application of a district-level panel-data model to evaluate surveillance cost-effectiveness in sub-Saharan Africa, employing a two-way fixed effects model to control for unobserved confounders.

*This analysis provides evidence for geographically tailored resource allocation in public health surveillance.*

<ul style="list-style-type: none"><li>• Provides a methodological framework for longitudinal evaluation of health systems in low-resource settings.</li></ul>	
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