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A Bayesian Hierarchical Model for the Reliability Assessment of Public Health Surveillance Systems in Ethiopia, 2000–2026

Mekdes Abebe[1]
[1] *Department of Clinical Research, Addis Ababa University*
Correspondence: mabebe@yahoo.com

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Author notes

Mekdes Abebe is affiliated with Department of Clinical Research, Addis Ababa University and focuses on Medicine research in Africa.

ABSTRACT

Background: Public health surveillance systems are critical for disease control, yet their reliability in resource-limited settings is often uncertain. Existing evaluation frameworks lack robust quantitative methods to integrate heterogeneous data and account for hierarchical data structures inherent in national surveillance networks.

Purpose and objectives: This study aimed to develop and apply a novel Bayesian hierarchical model to quantitatively assess the reliability of a national public health surveillance system, using Ethiopia as a case study. The objective was to estimate system completeness and timeliness while quantifying uncertainty.

Keywords: *Bayesian hierarchical modelling, public health surveillance, reliability assessment, sub-Saharan Africa, Ethiopia, health systems evaluation, infectious disease monitoring*

Article Highlights

- National surveillance reliability estimated at 0.72 with clear regional inequities.
- Bayesian hierarchical model quantifies uncertainty in performance metrics.
- Completeness emerges as a more significant constraint than timeliness.
- Posterior probability of 0.94 supports a positive reliability trend.

Methodological Contribution

Introduces a Bayesian hierarchical model integrating multi-level reporting data to assess surveillance reliability while formally quantifying uncertainty—a robust alternative to conventional evaluation frameworks.

This study provides a quantitative framework for monitoring and strengthening public health surveillance in resource-limited settings.