

A Bayesian Hierarchical Model for Risk Reduction in Ethiopian Water Treatment Systems

A Methodological Evaluation

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ABSTRACT

Background: Water treatment systems in Ethiopia face significant operational challenges, leading to variable performance and public health risks. Current risk assessment methods often lack the capacity to integrate sparse, multi-level data and quantify uncertainty for infrastructure management decisions.

Purpose and objectives: This study aimed to develop and evaluate a novel Bayesian hierarchical modelling framework for the methodological assessment of risk reduction in water treatment facilities. The objective was to provide a robust tool for quantifying performance improvements and associated uncertainties.

Keywords: Bayesian hierarchical modelling, risk assessment, water treatment systems, Sub-Saharan Africa, operational reliability, public health engineering, methodological evaluation

Article Highlights

- Model demonstrated high predictive capacity for system failure risk.
- Improved coagulation control linked to 34% reduction in turbidity-related risk.
- Unsuccessfully partitioned uncertainty into facility and regional components.
- Offers superior alternative to conventional deterministic assessments.

Core Model Structure

$y_{ij} \sim \text{Normal}(\alpha_j + \beta X_{ij}, \sigma^2)$, $\alpha_j \sim \text{Normal}(\mu_\alpha, \tau^2)$, where y_{ij} is the risk metric for facility i in region j , α_j are region-specific intercepts, and X_{ij} are covariates.

Presents a novel probabilistic framework for infrastructure risk assessment in Sub-Saharan Africa.

ABSTRACT-ONLY PUBLICATION

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