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A Bayesian Hierarchical Model for Reliability Diagnostics and Maintenance Policy in Rwandan Water Treatment Systems

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ABSTRACT

Background: The reliability of water treatment infrastructure is a critical determinant of public health and economic development. In many developing nations, maintenance policies are often reactive, leading to inefficient resource allocation and service disruption. A systematic, data-driven approach to reliability assessment is therefore essential for effective infrastructure management.

Purpose and objectives: This policy analysis article develops and evaluates a novel Bayesian hierarchical model to diagnose reliability and inform maintenance strategies for water treatment systems. The primary objective is to provide a robust methodological framework for quantifying system failure risks and optimising intervention schedules.

Keywords: *Bayesian hierarchical modelling, infrastructure reliability, maintenance policy, water treatment systems, Sub-Saharan Africa*

Article Highlights

- Bayesian hierarchical model quantifies failure risks across water treatment components.
- Reveals substantial reliability heterogeneity, with filtration units at higher risk.
- Provides statistically rigorous tool for condition-based maintenance policy.
- Enables data-driven allocation of maintenance budgets based on posterior risk.

Policy Implication

Investment and maintenance budgets should be informed by probabilistic reliability assessments, not just historical expenditure.

This analysis provides a framework for data-driven infrastructure management in developing contexts.