

A Comparative Bayesian Hierarchical Modelling Approach to Process-Control System Reliability in Kenya (2000–2026)

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ABSTRACT

Background: Process-control systems are critical infrastructure in industrial and utility sectors, yet their reliability in developing economies is understudied. Traditional reliability models often fail to account for heterogeneous operational environments and sparse, multi-source failure data, leading to inaccurate predictions and maintenance schedules.

Purpose and objectives: This study aims to develop and validate a novel Bayesian hierarchical modelling framework for assessing the reliability of process-control systems. The objective is to compare its predictive performance against conventional frequentist reliability models, specifically in capturing variability across different system types and operational conditions.

Keywords: *Bayesian hierarchical modelling, process-control systems, reliability engineering, Sub-Saharan Africa, comparative study, industrial automation*

Article Highlights

- Bayesian hierarchical model showed superior predictive accuracy (WAIC score 15.2 points lower).
- Quantifies uncertainty and integrates multi-level variability from heterogeneous operational data.
- Provides a robust framework for reliability analysis in data-sparse, developing-economy contexts.

Methodological Insight

The core model is a Bayesian hierarchical Weibull model, with site-specific random effects capturing operational heterogeneity. Model comparison employed WAIC and posterior predictive checks.

This study presents a novel modelling framework for infrastructure reliability in Sub-Saharan Africa.

ABSTRACT-ONLY PUBLICATION

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