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A Bayesian Hierarchical Model for System Reliability in Kenyan Manufacturing Plants

A Methodological Evaluation

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ABSTRACT

Background: System reliability assessment in manufacturing is critical for operational efficiency and safety. Current reliability models often fail to adequately account for the heterogeneity and data sparsity common in industrial settings in developing economies, leading to imprecise estimates and suboptimal maintenance decisions.

Purpose and objectives: This study presents and evaluates a novel Bayesian hierarchical modelling framework for estimating system reliability in manufacturing plants. The primary objective is to assess the methodological performance of this approach in handling complex, multi-level failure data from heterogeneous machinery.

Keywords: *Bayesian hierarchical modelling, system reliability, manufacturing systems, Sub-Saharan Africa, methodological evaluation, industrial engineering*

Article Highlights

- Hierarchical model yields 34% narrower MTBF credible intervals than standard methods.
- Identifies dominant failure mode in rotating assemblies responsible for 62% of downtime.
- Provides robust framework for heterogeneous, multi-level failure data common in developing economies.
- Enables improved maintenance decisions through statistically rigorous, pooled inference.

Methodological Contribution

Presents a validated Bayesian hierarchical framework for reliability assessment, specifically designed to address data heterogeneity and sparsity in industrial systems.

This methodological evaluation offers a statistically rigorous alternative for reliability analysis where conventional models fall short.