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A Bayesian Hierarchical Model for the Reliability Assessment of Industrial Machinery Fleets in Uganda

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Moses Ssekandi^{1,2} | Patience Auma¹ | Nakato Kigozi¹
David Kibuuka^{3,4}

¹ Uganda National Council for Science and Technology (UNCST)

² Makerere University, Kampala

³ Medical Research Council (MRC)/UVRI and LSHTM Uganda Research Unit

⁴ Department of Mechanical Engineering, Makerere University, Kampala

Correspondence: mssekandi@gmail.com

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ABSTRACT

Background: The reliability assessment of industrial machinery fleets in developing economies is often hampered by sparse, heterogeneous, and censored failure data, leading to imprecise maintenance planning and resource allocation.

Purpose and objectives: This study develops and validates a novel Bayesian hierarchical modelling framework to estimate the reliability of heterogeneous machinery fleets operating in Uganda, providing robust failure rate estimates and quantifying uncertainty for improved asset management.

Keywords: Bayesian hierarchical modelling, reliability engineering, industrial machinery, Sub-Saharan Africa, censored data, maintenance optimisation, developing economies

Article Highlights

- A novel Bayesian hierarchical Weibull model integrates sparse, heterogeneous fleet data.
- Quantifies significant group-level variance ($\sigma = 0.78$) across machinery types.
- Provides precise reliability estimates with 95% credible intervals under data-scarce conditions.
- Demonstrates practical utility for maintenance optimisation in developing economies.

Methodological Core

The model structure: $R_i(t) = \exp(-(\lambda_i t)^\kappa)$, where $\log(\lambda_i) = \alpha + \beta X_i + u_{g[i]}$, with $u_{g[i]} \sim N(0, \sigma^2)$ capturing random group effects.

This study provides a statistically rigorous framework for reliability assessment with censored, heterogeneous data.

ABSTRACT-ONLY PUBLICATION

This is an abstract-only publication. The complete research paper with full methodology, results, discussion, and references is available upon request.

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