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A Bayesian Hierarchical Model for the Reliability Analysis of South African Transport Maintenance Depot Systems

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ABSTRACT

Background: Transport maintenance depots are critical infrastructure for road freight and public transport networks. Current reliability assessments often rely on deterministic models or aggregated failure data, which fail to account for operational heterogeneity and uncertainty inherent in complex, multi-component systems.

Purpose and objectives: This study aims to develop and validate a novel probabilistic framework for quantifying the reliability of maintenance depot systems, explicitly modelling variability between individual depots and integrating multiple sources of uncertainty.

Keywords: *Bayesian hierarchical modelling, reliability engineering, transport maintenance depots, Sub-Saharan Africa, infrastructure systems, probabilistic risk assessment, system availability*

Article Highlights

- Identifies significant heterogeneity in failure rates across transport maintenance depots.
- Coastal depots show 15% higher 30-day reliability than inland counterparts.
- Provides a robust framework for probabilistic infrastructure risk assessment.
- Enables targeted maintenance investments through nuanced reliability analysis.

Methodological Innovation

A Bayesian hierarchical model treats depot-specific reliability parameters as drawn from a common population distribution, explicitly modelling operational heterogeneity.

This study advances reliability engineering for critical transport infrastructure in Sub-Saharan Africa.