CASE STUDY

A Bayesian Hierarchical Model for Risk Reduction in Ethiopian Transport Maintenance Depot Systems

A Methodological Evaluation

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ABSTRACT

Background: Transport maintenance depots are critical infrastructure for road safety and economic productivity. In many developing nations, these systems face complex, multi-level risks from operational, logistical, and environmental factors, yet lack robust, data-informed frameworks for systematic risk assessment and reduction.

Purpose and objectives: This case study presents a methodological evaluation of a novel Bayesian hierarchical model designed to quantify and prioritise risk reduction within transport maintenance depot systems. The objective is to demonstrate the model's applicability and utility for engineering decision-making in a resource-constrained context.

Keywords: *Bayesian hierarchical modelling, risk reduction, transport maintenance depots, Sub-Saharan Africa, infrastructure resilience, developing economies, methodological evaluation*

Article Highlights

- Hierarchical model quantifies multi-level risks across regional, depot, and workshop tiers.
- Reveals significant regional variability obscured in aggregate analyses.
- Provides statistically rigorous framework for resource-constrained contexts.
- Posterior distributions inform targeted interventions with measurable uncertainty.

Core Methodological Insight

The Bayesian hierarchical structure $\mu_{ij} = \alpha + \alpha_{j[i]} + \beta X_{ij}$ with group-level priors enables separation of shared and context-specific risk factors, crucial for heterogeneous depot networks.

This evaluation demonstrates how hierarchical modelling transforms sparse operational data into strategic risk intelligence.

📄 ABSTRACT-ONLY PUBLICATION

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