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A Bayesian Hierarchical Model for the Reliability Assessment of Railway Maintenance Depot Systems in Ethiopia

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ABSTRACT

Background: The reliability of railway maintenance depot systems is critical for operational continuity and safety, yet quantitative assessment methods tailored to the specific operational and environmental conditions of developing networks are lacking. Existing reliability models often fail to account for hierarchical data structures and inherent uncertainties in maintenance processes.

Purpose and objectives: This article presents a novel Bayesian hierarchical modelling framework for the reliability assessment of railway maintenance depot systems. The primary objective is to provide a robust methodology that integrates multi-level operational data to quantify system reliability and identify key influencing factors.

Keywords: *Bayesian hierarchical modelling, reliability assessment, railway maintenance depots, Sub-Saharan Africa, transport infrastructure, systems engineering, maintenance methodology*

Article Highlights

- A three-level Bayesian hierarchical model quantifies reliability in maintenance depot systems.
- Case study application reveals depot practices are more influential than component age on failure rates.
- The framework provides robust uncertainty quantification via posterior credible intervals.
- Methodology supports a shift from reactive to predictive maintenance strategies.

Methodological Insight

The model structures failure rates hierarchically, with depot-level parameters drawn from a common hyperprior, enabling analysis of variance across system levels.

This study presents a novel modelling framework with direct application to maintenance optimisation in developing railway networks.