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A Bayesian Hierarchical Model for the Cost-Effectiveness Evaluation of Transport Maintenance Depot Systems in Nigeria

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ABSTRACT

Background: Transport maintenance depots are critical infrastructure for road network functionality, yet systematic, data-driven frameworks for evaluating their cost-effectiveness are lacking, particularly in developing economies. Existing approaches often rely on deterministic analyses that fail to account for operational variability and hierarchical data structures inherent in depot systems.

Purpose and objectives: This study develops and applies a novel Bayesian hierarchical model to evaluate the cost-effectiveness of transport maintenance depot systems. The objective is to provide a robust methodological framework that quantifies efficiency while formally incorporating uncertainty and multi-level data dependencies.

Keywords: *Bayesian hierarchical modelling, cost-effectiveness analysis, transport maintenance depots, Nigeria, infrastructure evaluation, road networks, developing countries*

Article Highlights

- Identifies substantial heterogeneity in depot performance with 30% operating below cost-effectiveness frontier.
- Model reveals inefficiency primarily driven by spare parts inventory management practices.
- Provides statistically robust framework incorporating multi-level data dependencies and uncertainty.
- Offers probabilistic assessment for infrastructure managers to prioritise resource allocation.

Methodological Innovation

A Bayesian hierarchical model integrates cost, throughput, and asset condition data with random effects for depot-level variation, estimated via MCMC simulation.

This study presents a novel probabilistic framework for infrastructure evaluation in developing economies.