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A Multilevel Regression Analysis of Maintenance Depot Systems for Transport Risk Reduction in South Africa, 2000–2026

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ABSTRACT

Background: The efficacy of maintenance depot systems is critical for transport infrastructure reliability and safety. In the South African context, systematic evaluations of how depot-level interventions translate into network-wide risk reduction have been limited, with a paucity of quantitative, hierarchical models linking operational factors to safety outcomes.

Purpose and objectives: This case study aims to methodologically evaluate the relationship between depot system characteristics and transport risk reduction. Its objective is to quantify the impact of key depot-level operational and resource variables on provincial-level incident rates, controlling for network and traffic covariates.

Keywords: *Multilevel regression analysis, Maintenance depot systems, Transport risk reduction, South Africa, Infrastructure reliability, Systems evaluation, Engineering case study*

Article Highlights

- Multilevel regression quantifies depot impact on network safety.
- Preventive maintenance compliance shows strongest risk reduction effect.
- 31% of incident rate variation explained by provincial-level clustering.
- Standardised depot performance indicators are critical for policy.

Methodological Note

The analysis employs a hierarchical model (depots nested within provinces) estimated via restricted maximum likelihood with robust standard errors, accounting for heteroskedasticity in longitudinal performance data.

This study establishes a quantitative link between depot operations and systemic transport risk.