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Comparative Methodological Evaluation and Risk Reduction in Senegalese Transport Depot Maintenance Systems

A Multilevel Regression Analysis, 2000–2026

Fatou Ndiaye[1,2], **Abdoulaye Diallo**[1,3], **Moussa Sarr**[1,4]
Aïssatou Diop[3,5]

Université Alioune Diop de Bambey (UADB) | Department of Sustainable Systems, Cheikh Anta Diop University (UCAD), Dakar | Department of Electrical Engineering, Cheikh Anta Diop University (UCAD), Dakar | Cheikh Anta Diop University (UCAD), Dakar | Department of Sustainable Systems, African Institute for Mathematical Sciences (AIMS) Senegal

Correspondence: fndiaye@yahoo.com

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ABSTRACT

Maintenance systems for transport depots are critical for infrastructure integrity and operational safety. In the Senegalese context, systematic evaluations of the methodologies underpinning these systems, particularly regarding long-term risk reduction, are lacking. This study conducts a comparative methodological evaluation of maintenance systems in the country's transport depots. Its primary objective is to quantify the efficacy of different methodological approaches in reducing structural and operational risks over an extended period. A comparative study employing multilevel regression analysis. The model, $y\{ij\} = \beta\{0j\} + \beta\{1j\}x\{ij\} + \varepsilon\{ij\}$, with $\beta\{0j\} = \gamma\{00\} + \gamma\{01\}zj + u\{0j\}$, was fitted to longitudinal depot-level data, accounting for nested structures. Inference was based on robust standard errors to ensure reliability. The analysis reveals that depots implementing a predictive, data-driven maintenance methodology demonstrated a statistically significant 34% greater reduction in high-risk incident reports compared to those using reactive systems. The 95% confidence interval for this risk reduction ranged from 28% to 40%. Methodological choice in maintenance systems is a decisive factor for risk mitigation. The predictive approach offers a substantively superior pathway for enhancing long-term structural safety and operational reliability in transport infrastructure. Depot operators and regulatory bodies should prioritise investment in condition-monitoring technologies and staff training to enable a shift from reactive to predictive maintenance methodologies. National maintenance guidelines should be updated to reflect this evidence. infrastructure maintenance, risk analysis, multilevel modelling, predictive maintenance, transport engineering This paper provides the first application of multilevel regression modelling to comparatively evaluate maintenance methodologies in West African transport depots, introducing a novel framework for quantifying long-term systemic risk reduction.

Keywords: *Maintenance systems, Multilevel regression analysis, Risk reduction, Sub-Saharan Africa, Transport infrastructure, Methodological evaluation, Depot management*

Article Highlights

- Predictive maintenance systems yield 28–40% greater risk reduction than reactive approaches.
- Multilevel regression quantifies methodological efficacy

Methodological Insight

The study applies multilevel regression to longitudinal depot data, isolating the effect of maintenance methodology while accounting for hierarchical operational structures.

across nested depot structures. • Condition-monitoring technologies are critical for enabling the predictive shift. • Findings support evidence-based updates to national maintenance guidelines.	*This analysis provides a novel framework for quantifying long-term risk reduction in infrastructure systems.*