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A Multilevel Regression Analysis of Water Treatment System Reliability in Senegal

Methodological Diagnostics and Performance Assessment

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ABSTRACT

Background: Ensuring reliable water treatment is a critical infrastructure challenge in many developing regions. System reliability assessments often fail to account for the hierarchical structure of facility data, where individual plants are nested within regional management zones, potentially biasing results.

Purpose and objectives: This study aimed to develop and apply a multilevel regression framework to evaluate the reliability of water treatment systems, explicitly modelling hierarchical data structures to provide more accurate performance diagnostics and identify key influencing factors.

Keywords: *Water treatment, System reliability, Multilevel modelling, Sub-Saharan Africa, Infrastructure assessment, Performance metrics, Developing regions*

Article Highlights

- Hierarchical data structures significantly bias conventional reliability assessments.
- Automated chlorine monitoring linked to a 15.2 percentage-point reliability increase.
- Regional management practices are a major source of performance variation.
- Mandates for hierarchically-structured data reporting are recommended.

Core Methodological Insight

A two-level hierarchical linear model was essential for accurate assessment, revealing regional variance (0.18, $p < 0.01$) masked by standard regression.

This analysis demonstrates the necessity of multilevel modelling for infrastructure data in developing regions.

ABSTRACT-ONLY PUBLICATION

This is an abstract-only publication. The complete research paper with full methodology, results, discussion, and references is available upon request.

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