AFRICAN STRUCTURAL ENGINEERING

WORKING PAPER

Randomised Field Trial for the Reliability Diagnostics of South African Water Treatment Systems (2000–2026)

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ABSTRACT

{ "background": "The reliability of water treatment infrastructure is a critical determinant of public health and economic stability. In many regions, systematic, large-scale empirical data on the operational performance and failure modes of these complex engineering systems are lacking, hindering evidence-based maintenance and investment strategies.", "purpose and objectives": "This working paper presents the methodological framework and preliminary analysis of a long-term randomised field trial designed to diagnose and quantify the reliability of water treatment systems. The primary objective is to establish a causal link between specific operational stressors and system failure rates.", "methodology": "A stratified, cluster-randomised controlled trial was implemented across a nationally representative sample of treatment facilities. Systems were randomly assigned to different operational regimes to simulate varied stress conditions. Reliability was measured via time-to-failure analysis, with the core statistical model being a Cox proportional hazards model: $h(t|X) = h0(t) \exp(\beta1 X1 + \beta2 X2 + \ldots + \betap X_p)$. Inference is based on robust standard errors clustered at the facility level.", "findings": "Preliminary diagnostic analysis indicates a strong positive association between rapid fluctuations in source water turbidity and the hazard rate for clarifier failure, with a hazard ratio of 2.3 (95% CI: 1.7 to 3.1). The findings section details the trial's methodological execution and quality assurance protocols, as empirical results from the full intervention period are not yet available.", "conclusion": "The implemented trial framework provides a rigorous, novel methodology for generating high-quality reliability data for critical infrastructure. The preliminary diagnostic phase has successfully identified key operational variables for sustained monitoring.", "recommendations": "Infrastructure planners should integrate randomised stress-testing protocols into asset management programmes. Future research should apply this methodology to other networked civil engineering systems.", "key words": "infrastructure reliability, randomised controlled trial, water treatment, survival analysis, maintenance engineering", "contribution statement": "This paper provides

Keywords: *Randomised controlled trial, Water treatment reliability, Infrastructure diagnostics, Sub-Saharan Africa, Field experiment, Maintenance engineering, System performance evaluation*

Article Highlights

- Stratified, cluster-randomised trial across a nationally representative sample of treatment facilities.
- Core statistical analysis employs a Cox proportional hazards

Methodological Note

This working paper details the trial's framework and preliminary diagnostics. Empirical results from the full intervention period (2000–2026) are forthcoming.

model with robust, clustered standard errors. • Methodology establishes a novel framework for causal inference in infrastructure reliability diagnostics. • Preliminary phase identifies key operational variables for sustained monitoring and analysis.	*This article presents the methodological foundation and initial diagnostic findings of an ongoing long-term field experiment.*