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A Randomised Field Trial Methodology for Evaluating Risk Reduction in Tanzanian Power-Distribution Networks

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ABSTRACT

{ "background": "Power-distribution networks in sub-Saharan Africa face unique challenges, including environmental stressors and variable maintenance regimes, which increase failure risks. Existing evaluation methods for equipment performance often rely on laboratory tests or retrospective data, lacking the rigour to establish causal evidence of risk reduction under real-world operating conditions.", "purpose and objectives": "This article presents a novel methodology for conducting a randomised field trial (RFT) to robustly evaluate the comparative performance of different power-distribution equipment systems. The primary objective is to detail a framework for measuring causal impacts on failure rates and safety outcomes within an active grid.", "methodology": "The RFT methodology involves the random assignment of new equipment types (e.g., polymer-housed surge arresters versus porcelain) or maintenance protocols to distinct network segments. The primary outcome is the time-to-failure, analysed using a Cox proportional hazards model: $h(t|X) = h0(t) \exp(\beta 1 X1 + \beta 2 X_2 + \varepsilon)$, where X represents treatment assignment and environmental covariates. Inference will be based on robust standard errors clustered at the substation level.", "findings": "As a methodology article, this paper presents no empirical results from a completed trial. However, the proposed design is shown through simulation to achieve 80% power to detect a hazard ratio of 0.65 for the primary intervention, assuming a baseline annual failure rate of 8%.", "conclusion": "The outlined RFT framework provides a rigorous, evidence-based approach for evaluating infrastructure interventions in power networks, moving beyond observational comparisons to establish causal evidence of performance and risk reduction.", "recommendations": "Utility engineers and researchers should adopt randomised field trials for major equipment rollouts. Key implementation steps include securing operational partnerships, defining clear randomisation units, and establishing real-time monitoring systems for primary outcome data.", "key words": "randomised controlled trial, distribution network, asset management, failure analysis, causal inference, field experiment

Keywords: *Randomised controlled trial, Power-distribution networks, Sub-Saharan Africa, Reliability engineering, Field testing, Risk assessment*

Article Highlights

- Proposes a novel randomised field trial (RFT) framework for power-distribution networks.
- Details methodology for random assignment of equipment to distinct network segments.
- Primary outcome is time-to-failure, analysed via Cox proportional hazards model.
- Framework designed to achieve 80% statistical power for

Methodological Innovation

The article presents a rigorous field-trial design for causal inference in infrastructure evaluation, addressing the limitations of laboratory tests and retrospective data common in the region.

This is a methodology paper; no empirical results from a completed trial are presented.

detecting meaningful risk reduction.	