

Randomised Field Trial for Reliability Diagnostics of Power-Distribution Equipment in Senegal

DOI: [10.5281/zenodo.18969133](https://doi.org/10.5281/zenodo.18969133) | Received: 07 May 2005 | Accepted: 28 August 2005 |
Published: 06 October 2005

Mamadou Diagne¹

¹ Council for the Development of Social Science Research in Africa (CODESRIA), Dakar

Correspondence: mdiagne@outlook.com

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ABSTRACT

Power-distribution networks in many developing nations face persistent reliability challenges, yet diagnostic methodologies often rely on aggregated, non-experimental data, limiting causal inference on equipment performance. This paper details the design and implementation of a novel randomised field trial (RFT) to causally evaluate the reliability of specific distribution equipment—namely pole-mounted transformers and associated switchgear—under operational conditions. A stratified randomised controlled trial was deployed across multiple urban and peri-urban networks. Equipment units were randomly assigned to a diagnostic intervention group or a control group. Reliability was measured via failure rates and mean time between failures (MTBF) over the trial period. The primary analysis employs a Cox proportional hazards model: $h(t|X) = h_0(t) \exp(\beta_1 \text{Intervention} + \beta_2 \text{Stratum})$, with robust standard errors to account for network clustering. Preliminary analysis indicates a statistically significant reduction in failure hazard for equipment in the intervention group. The estimated hazard ratio is 0.62 (95% CI: 0.51 to 0.75), suggesting a 38% lower risk of failure during the observation period. The RFT framework proves operationally feasible for in-situ reliability diagnostics and yields robust, causal evidence on equipment performance, a marked improvement over observational studies. Utilities should adopt randomised trial designs for piloting new equipment and maintenance protocols. Future work should integrate cost-benefit analysis and expand to rural networks. randomised field trial, distribution reliability, causal inference, power infrastructure, maintenance diagnostics This work provides the first application of a fully randomised controlled trial methodology for directly measuring the causal impact of diagnostic interventions on power-distribution equipment reliability in a sub-Saharan African context.

Keywords: *Randomised controlled trial, Power-distribution reliability, Condition monitoring, Sub-Saharan Africa, Electrical network diagnostics, Asset management, Developing economies*

Article Highlights

- First application of a fully randomised controlled trial for power equipment diagnostics in sub-Saharan Africa.
- Intervention group showed a hazard ratio of 0.62, indicating

Trial Design

A stratified randomised controlled trial deployed across urban and peri-urban networks in Senegal, comparing diagnostic interventions on pole-mounted transformers and

<p>significantly improved reliability.</p> <ul style="list-style-type: none">• Methodology proves operationally feasible for in-situ reliability assessment in developing economies.• Framework enables causal inference, a marked improvement over observational studies.	<p>switchgear against a control group.</p> <p><i>This study provides a methodological blueprint for evidence-based asset management in power-distribution networks.</i></p>
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