

Methodological Framework for Risk Reduction in South African Process-Control Systems

A Multilevel Regression Analysis

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ABSTRACT

Background: Process-control systems in industrial settings are critical for operational safety and efficiency. In the South African context, these systems face unique challenges from ageing infrastructure, variable maintenance regimes, and complex socio-technical environments. A robust methodological approach is required to quantify and mitigate associated risks effectively.

Purpose and objectives: This article presents a novel methodological framework for the quantitative evaluation of risk reduction in industrial process-control systems. The primary objective is to detail a multilevel regression procedure that isolates the effects of targeted engineering interventions from confounding operational and organisational factors.

Keywords: *process-control systems, multilevel regression analysis, risk reduction, industrial safety, Southern Africa, methodological framework, ageing infrastructure*

Article Highlights

- Proposes a three-level linear growth model for longitudinal, hierarchical data.
- Isolates engineering intervention effects from operational and organisational confounders.
- Provides a generalisable method for assessing risk reduction in layered industrial systems.
- Employs robust standard errors to account for potential heteroscedasticity.

Core Statistical Model

$y_{tij} = \beta_{0ij} + \beta_{1ij}(\text{Time}_{tij}) + \beta_{2ij}(\text{Intervention}_{tij}) + e_{tij}$, with random intercepts and slopes at subsystem and plant levels.

This article details a methodological framework; empirical results are from simulation studies.

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