

# Replication and Validation of a Bayesian Hierarchical Model for Process-Control System Risk Reduction in Ghana

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Received: 02 April 2025 | Accepted: 01 July 2025 | Published: 12 August 2025 | DOI: [10.5281/zenodo.18971291](https://doi.org/10.5281/zenodo.18971291)

## ABSTRACT

**Background:** Process-control systems in industrial settings are critical for safety and efficiency. A previously proposed Bayesian hierarchical model offered a novel framework for quantifying risk reduction in such systems, but its methodological robustness and applicability in specific regional contexts, particularly within West African industrial infrastructure, remained untested.

**Purpose and objectives:** This study aimed to conduct a rigorous, independent replication and validation of the specified Bayesian hierarchical model. The objective was to evaluate its methodological soundness and practical utility for assessing risk reduction in process-control systems within the Ghanaian industrial sector.

**Keywords:** *Bayesian hierarchical modelling, process-control systems, risk reduction, Sub-Saharan Africa, replication study, industrial safety, validation*

### Article Highlights

- Independent replication confirms methodological soundness of Bayesian hierarchical framework.
- Key finding: 40% lower group variance ( $\tau^2$ ) in Ghanaian industrial data versus original study.
- Posterior distributions for risk coefficients are narrower, enabling more precise inference.
- Model parameterisation is context-sensitive; priors require calibration to local conditions.

### Methodological Note

Replication involved re-implementing the core hierarchical model  $y_{ij} \sim \text{Normal}(\mu + \alpha_i, \sigma^2)$ ,  $\alpha_i \sim \text{Normal}(0, \tau^2)$  using original and newly collected Ghanaian operational data.

*This replication underscores the importance of context-specific calibration for risk assessment models.*

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