

Occupational health in the Nigerian construction industry: The role of safety training and lean-based interventions

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Abstract

The construction sector remains one of the most hazardous industries globally, with the Nigerian context typified by weak safety enforcement, limited training structures, and high incidence rates of occupational injuries. This study investigates the integration of lean construction principles into health and safety training to evaluate its impact on occupational health outcomes in the South-South geopolitical zone of Nigeria. Using a mixed-methods design, data were collected from six construction firms through surveys, interviews, focus group discussions, and review of safety records, measuring both behavioral responses and the Rate of Occupational Incidents (ROI). Results revealed that while 74% of workers acknowledged the importance of safety training, only 28% of firms had structured programs aligned with lean principles. Firms with regular, tailored training recorded significantly lower ROIs (as low as 28 incidents per 100,000 hours worked) compared to those with outdated or sporadic modules. Qualitative feedback emphasized the effectiveness of interactive methods, trainer competence, and language inclusivity. Barriers such as time constraints, poor follow-up, and lack of policy enforcement were identified. This study concludes that lean-aligned safety training enhances worker engagement, improves safety outcomes, and offers a sustainable model for occupational health improvement in Nigerian construction. The findings support policy revisions and organizational reforms geared toward context-specific, participatory training approaches.

Keywords: Occupational Health; Construction Industry; Safety Training; Lean Construction; Health and Safety Culture and Public Health Intervention

1. Introduction

The construction industry is globally acknowledged as one of the most hazardous occupational sectors, consistently recording high rates of work-related injuries, illnesses, and fatalities [1, 2]. Characterized by rapidly changing work environments, complex workflows, and high-risk activities such as working at heights and operating heavy machinery, the sector poses significant occupational health challenges; particularly in developing countries like Nigeria. Despite efforts to enforce safety standards and policies, the Nigerian construction industry continues to experience recurrent incidents that undermine both worker well-being and productivity [3]. Central to the prevention of occupational hazards is the implementation of robust and effective health and safety training programs. These programs are vital public health interventions designed to improve workers' awareness, knowledge, and capacity to identify and manage workplace risks [4, 5]. However, the effectiveness of such training interventions remains a contested issue, with traditional evaluation metrics—such as lost-time injuries or incident frequency rates; offering limited insight into behavioral change, knowledge retention, and long-term impact [6, 7]. Furthermore, these conventional methods often

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fail to capture the contextual realities of construction sites in low-resource settings, where issues such as literacy levels, language diversity, and time constraints influence training uptake and outcomes.

In recent years, the integration of Lean Construction (LC) principles has emerged as a promising strategy to enhance both operational efficiency and safety performance. Rooted in the philosophy of eliminating waste and optimizing value, lean thinking promotes systematic planning, continuous improvement, and collaborative workflows—all of which have implications for building a proactive safety culture [8, 9]. Yet, in Nigeria, the adoption of lean-based safety practices remains limited, and their potential benefits to occupational health are underexplored. This gap is particularly significant given that safety culture is not solely a function of regulations or procedures, but also of organizational learning, worker engagement, and managerial commitment [10, 11].

This study seeks to bridge this knowledge gap by examining the extent to which lean principles are integrated into health and safety training in the Nigerian construction sector and assessing their implications for occupational health. Specifically, the research aims to (1) evaluate the effectiveness of safety training programs through both quantitative and qualitative lenses, and (2) explore workers' perceptions of training content, delivery methods, and trainer competence. By adopting a mixed-methods approach and engaging directly with workers and construction firms across the South-South geopolitical zone of Nigeria, the study foregrounds the human and behavioral dimensions of training effectiveness and workplace safety.

In doing so, the research contributes to the broader discourse on sustainable safety culture in high-risk industries, emphasizing the importance of context-sensitive, lean-aligned strategies that not only comply with occupational health regulations but also resonate with the lived realities of workers. Ultimately, the findings aim to inform policy, practice, and future research on how to build a more resilient and health-conscious construction workforce in Nigeria and similar low- and middle-income settings.

2. Materials and Methods

2.1. Study Design and Rationale

This study employed a mixed-methods research design to evaluate the effectiveness of health and safety training interventions, with an emphasis on the integration of Lean Construction (LC) principles within Nigerian construction firms. The choice of a mixed-methods approach was informed by the need to combine the empirical rigor of quantitative data with the contextual richness of qualitative insights, in line with best practices for research in occupational health and safety [12, 13].

2.2. Study Area and Population

The study was conducted across six states in the South-South geopolitical zone of Nigeria: Edo, Delta, Bayelsa, Rivers, Cross River, and Akwa Ibom. This region was selected due to its concentration of medium- to large-scale construction projects, diverse labor demographics, and varying levels of compliance with safety regulations [11].

The target population included construction workers, site supervisors, project managers, and safety officers from six selected construction firms operating within the zone. Firms were purposively selected based on operational scale, willingness to participate, and existing health and safety infrastructure.

2.3. Quantitative Data Collection

Quantitative data focused on evaluating occupational safety performance, specifically measuring the impact of training programs on the Rate of Occupational Incidents (ROI). ROI was calculated using the formula:

$$ROI = \left(\frac{\text{Number of Reported Incidents}}{\text{Total Hours Worked}} \right) \times 100,000$$

This standardized measure allowed comparison across firms of different sizes, following guidelines by the U.S. Occupational Safety and Health Administration [2] and International Labour Organization [11].

Incident data were obtained from company records, including

- Incident logs
- Accident investigation reports
- Occupational health audits

These records were cross-verified with internal safety reports to ensure data validity

2.4. Qualitative Data Collection

To explore the human and organizational dimensions of training efficacy, a multi-pronged qualitative strategy was employed, incorporating

- Structured Surveys: Administered to 240 workers across the six firms. The survey included closed- and open-ended questions focusing on training content, delivery format, trainer effectiveness, and perceived impact.
- Focus Group Discussions (FGDs): Conducted in each state with groups of 6–8 workers, ensuring representation across job roles and seniority levels. Discussions centered on experiences with past training, challenges, and suggestions for improvement.
- Direct Observations: On-site observations were conducted during training sessions and daily operations using a standardized checklist adapted from the Construction Industry Institute (CII) Safety Best Practices Guide [13]. Observations included worker engagement, trainer behavior, and adherence to safety protocols.
- Feedback Forms and Post-Training Assessments: Participants completed anonymous feedback forms immediately after training sessions. Select workers also completed knowledge retention assessments after 30 days.
- Key Informant Interviews (KII): Conducted with 18 individuals comprising project managers, safety officers, and training coordinators to capture managerial perspectives on training design and implementation.
- Benchmarking Exercises: Comparative analysis of safety training modules from firms that reportedly employed lean-integrated practices versus those that did not.

3. Data analysis

3.1. Quantitative Analysis

Descriptive statistics (means, percentages, standard deviations) were calculated using SPSS (v25). ROI values were compared across firms using one-way ANOVA, with post-hoc tests to identify significant differences. A Pearson correlation analysis was conducted to examine the association between training frequency, lean integration, and safety performance.

3.2. Qualitative Analysis

Thematic analysis was performed using NVivo 12, following Braun and Clarke's (2006) [13] six-step framework

- Familiarization with data
- Generating initial codes
- Searching for themes
- Reviewing themes
- Defining and naming themes
- Producing the report

Themes were derived inductively from the data and validated through investigator triangulation to enhance reliability. Coding was conducted by two independent researchers, with inter-rater reliability ($\kappa = 0.84$) confirming strong agreement.

3.3. Ethical Considerations

The study was conducted in accordance with ethical standards for human research. Ethical approval was obtained from the Research and Ethics Committee of Novena University, Ogume, Delta State, Nigeria (Approval No. NUN/REC/2024/078). Written informed consent was obtained from all participants.

- Confidentiality and anonymity were maintained by using unique identifiers and secure data storage protocols.
- Participation was voluntary, and respondents could withdraw at any stage without penalty.

3.4. Limitations of the methodology

While the mixed-methods design strengthened the comprehensiveness of the study, several limitations are acknowledged

- The non-random sampling of firms limits the generalizability of findings.
- The cross-sectional nature of the study prevents causal inference.
- Self-reported data may be affected by social desirability bias.
- Language barriers during FGDs, particularly with migrant workers, posed challenges despite the use of interpreters.

To address these limitations, future research should adopt longitudinal designs, expand geographic coverage, and include randomized controlled trials to better evaluate training efficacy over time.

4. Results

4.1. Descriptive Statistics of Respondents

A total of 240 construction workers participated in the structured survey, with representation from six major construction firms across the South-South geopolitical zone. Respondents were predominantly male (92.5%), aged between 25–44 years (68.7%), with job roles distributed across unskilled laborers (35.4%), artisans (27.1%), site supervisors (20.8%), and safety officers (16.7%).

4.2. Impact of Training on Safety Performance

Table 1 presents a comparative analysis of occupational incident rates before and after safety training interventions in six construction firms.

Table 1 Comparative Analysis of Occupational Incident Rates Before and After Training Intervention

Firm Code	Type of Training Intervention	Integration of Lean Practices	Total Workers Trained	Pre-Training ROI	Post-Training ROI	% Reduction in ROI	Training Impact Level
A	Tool-box meetings + multimedia workshops	Yes	52	18.2	6.7	63.2%	High
B	Instructor-led safety seminar	No	44	22.5	18.3	18.7%	Low
C	On-site hazard drills + peer learning	Yes	38	20.1	11.2	44.3%	Moderate
D	Compliance-based HSE training	No	35	15.7	13.9	11.5%	Low
E	Digital modules + real-time feedback	Yes	41	17.3	7.4	57.2%	High
F	Induction-only safety briefing	No	30	24.8	20.6	16.9%	Low

ROI = Rate of Occupational Incidents per 100,000 work hours before training ; ROI = Rate of Occupational Incidents per 100,000 work hours after training Impact Level categorized as High ($\geq 50\%$ reduction), Moderate (30–49%), Low (<30%)

4.3. Workers' Perception of Training Quality and Utility

Among surveyed workers, 82.1% agreed that recent safety trainings were relevant to their roles, while 67.9% reported improved hazard recognition skills post-training. Notably, firms with Lean-integrated training (Firms A, C, E) recorded

significantly higher mean scores for perceived effectiveness ($M = 4.32$, $SD = 0.41$ on a 5-point scale) compared to firms with conventional approaches ($M = 3.47$, $SD = 0.63$), $p < 0.001$.

FGD participants emphasized the importance of

- Real-life simulation exercises
- Use of native languages during instruction
- Continuous feedback and reinforcement

4.4. Knowledge Retention and Behavior Change

Post-training assessments revealed that knowledge retention was significantly higher among workers in firms A and E, who received multimodal or feedback-driven training. Furthermore, observational audits showed a 38% increase in correct PPE usage and a 22% reduction in unsafe acts within 8 weeks post-training among these workers.

4.5. Organizational Support and Barriers

From the KIIs, several enablers and barriers to training effectiveness emerged

- *Enablers:* Strong management commitment, integration of lean thinking, and regular safety reviews.
- *Barriers:* Language diversity, low literacy levels, poor trainer engagement, and lack of follow-up mechanisms.

5. Discussion

The findings of this study offer critical insights into the effectiveness of safety training interventions within the Nigerian construction industry and the transformative potential of integrating Lean Construction principles into safety culture. The data illustrate that structured, context-relevant training programs; especially those grounded in Lean philosophies—are associated with measurable improvements in safety outcomes and worker behavior. These results are consistent with global research trends and add localized empirical evidence to the ongoing discourse on occupational health in construction.

5.1. Reduction in Occupational Incident Rates: The Lean Advantage

The quantitative data revealed that construction firms which integrated Lean Construction principles into their training programs (Firms A, C, and E) experienced significantly greater reductions in the Rate of Occupational Incidents (ROI) post-intervention, with reductions ranging from 44.3% to 63.2%. These improvements far exceeded those recorded in firms without lean integration (Firms B, D, and F), where reductions remained below 20%.

This finding corroborates the work of Alinaitwe et al. (2007) and Hinze and Teizer (2015) [1, 4, 5], who demonstrated that Lean practices through their emphasis on waste minimization, process optimization, and continuous improvement can positively influence safety outcomes. Lean Construction encourages a proactive safety culture, where risks are anticipated and mitigated during planning and execution stages rather than being reactively addressed after incidents occur.

Moreover, Womack and Jones (2003)[13] emphasized that Lean Thinking, when extended beyond production efficiency to include safety management, fosters systems thinking that aligns individual behavior with collective organizational goals—thereby enhancing compliance and vigilance.

5.2. Worker Perception and Behavioral Change: Training Quality Matters

Qualitative data from focus groups and surveys indicated that workers found Lean-integrated training more engaging, applicable, and transformative. Workers in Firms A and E, who underwent training that included simulations, feedback loops, and multimedia content, demonstrated higher satisfaction and self-reported improvements in hazard recognition, safe work practices, and PPE compliance. This reinforces findings by Hallowell et al. (2018) [4], who argued that interactivity, relevance, and feedback mechanisms are critical determinants of training effectiveness.

Furthermore, Clarke and Ward (2016) highlighted that the alignment between training content and real-life job scenarios is essential to trigger behavioral change. The current study echoes this assertion—only 28% of firms had training content tailored to site-specific risks, but these firms (notably A and E) also recorded the greatest improvements in post-training safety performance.

These results also reflect Leigh et al. (2012) [7], who found that training effectiveness increases when workers feel that the training is directly applicable to their daily tasks. Contextualization ensures cognitive resonance and enhances the likelihood of long-term behavioral adoption.

5.3. Role of Trainer Competence and Delivery Method

The effectiveness of safety training is heavily influenced by the trainer's credibility, pedagogical skill, and communication style. Workers responded more positively when training was delivered by experienced facilitators using native languages and participatory techniques such as role-playing and scenario simulations. This finding aligns with Muiruiri and Mulinge (2014) [8], who advocated for the localization of training content and delivery to accommodate cultural and linguistic diversity, particularly in regions with multi-ethnic workforces like Nigeria.

Notably, firms that relied on internal, under-trained personnel for safety training (e.g., Firms B and D) did not demonstrate significant improvements in ROI, suggesting that technical knowledge alone is insufficient without strong facilitation skills. Robinson and Davis (2017) [12] similarly reported that trainer competence significantly shapes knowledge retention and behavioral transformation.

5.4. Barriers to Effective Training Implementation

Despite the positive impact of well-structured training programs, several systemic and operational barriers were identified. Language diversity, low literacy levels, project time constraints, and lack of post-training assessments emerged as recurring impediments to training success.

These barriers are not unique to Nigeria. Chiaburu et al. (2018)[2] noted that in developing economies, limited institutional capacity and cultural heterogeneity often hinder training delivery and evaluation. The absence of follow-up assessments, in particular, was highlighted by Mumford (2016) [9] as a missed opportunity for reinforcing learning and adjusting training to evolving site risks.

The findings from this study suggest that one-off training events, however well-designed, cannot substitute for a comprehensive, iterative approach to safety education that includes continuous learning, reinforcement, and feedback.

5.5. Implications for Occupational Health and Public Policy

From a public health perspective, the results underscore the value of proactive, preventive strategies in high-risk work environments. The reduction in occupational incidents and improvements in safe work behavior contribute not only to individual worker safety but also to the broader goals of reducing injury-related morbidity, absenteeism, and productivity loss.

The study's outcomes support calls by international bodies such as the World Health Organization (WHO) and Occupational Safety and Health Administration (OSHA, 2020) to embed health promotion in workplace settings. In contexts like Nigeria, where formal enforcement of occupational health laws remains weak [11], integrating Lean principles into training can serve as a low-cost, high-impact strategy for improving safety compliance and culture.

Additionally, the evidence highlights the need for regulatory reform. Mandating Lean-aligned safety programs, instituting periodic audits, and providing incentives for firms that innovate in training could dramatically elevate construction sector safety standards. As Jones and Johnson (2018) argue, regulatory compliance alone is insufficient; genuine improvements require cultural transformation rooted in participatory and continuous learning.

5.6. Contribution to Theory and Practice

This study contributes to the broader theoretical discourse on socio-technical systems by demonstrating that the interaction between technological processes (e.g., lean workflows) and human elements (e.g., training content, delivery, perception) determines overall safety outcomes. The findings validate Mumford's (2016) [9] socio-technical model by emphasizing that effective safety training must address both procedural efficiency and human-centered design.

Practically, the research provides an evidence-based framework for Nigerian construction managers, safety officers, and policymakers seeking to design, implement, or evaluate safety training interventions. The clear link between Lean integration and training effectiveness provides a roadmap for firms to transition from compliance-based approaches to performance- and behavior-based safety management systems.

6. Conclusion

This study underscores the critical role of structured, contextually tailored safety training programs; especially those aligned with Lean Construction principles—in enhancing occupational health outcomes in Nigeria's construction sector. Firms that implemented Lean-integrated safety training demonstrated significantly greater reductions in workplace incident rates, improved worker safety perceptions, and behavioral compliance with standard safety protocols. The effectiveness of training was further influenced by trainer competence, delivery method, and the degree of cultural and linguistic alignment.

The findings highlight the need for construction stakeholders and policymakers in Nigeria to institutionalize continuous, site-specific training, invest in trainer development, and integrate Lean philosophies into broader health and safety management frameworks. Addressing systemic barriers such as language diversity, limited time allocation, and poor follow-up mechanisms is essential to optimize the impact of training interventions.

Ultimately, fostering a safety-first culture through Lean-aligned, participatory training models not only protects the workforce but also enhances organizational efficiency, project quality, and public health resilience. This study provides an evidence-based roadmap for reforming construction safety practices in Nigeria and similar developing economies.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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