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Effectiveness of Safety Guards in the Reduction of Occupational Injuries Among Construction Workers in Delta State, Nigeria

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Abstract- The construction industry remains one of the most hazardous sectors globally, with consistently high rates of occupational fatalities and injuries. Despite advancements in safety technologies and regulatory frameworks, construction workers continue to face serious risks including falls, machinery accidents, and exposure to hazardous materials. Safety guards serve as critical protective measures, yet their effectiveness in reducing injuries varies considerably across construction sites. This study assessed the effectiveness of safety guards in reducing the frequency and severity of occupational injuries among construction workers in Delta State, Nigeria. Specifically, it examined the types of safety guards used, factors influencing workers' adherence to safety protocols, the effectiveness of safety guards in injury reduction, and challenges encountered in their implementation. A cross-sectional quantitative design was employed, involving 388 construction workers, site supervisors, safety officers, and technical personnel from selected construction sites in Delta State. Data were collected using structured questionnaires and analyzed using descriptive statistics and chi-square tests, with a significance level set at $p < 0.05$. Machine guards, edge protection, scaffold guardrails, perimeter fencing, and handrail systems were the most commonly used safety guards (mean = 3.1). Factors significantly influencing adherence included management commitment (mean = 3.1), safety training (mean = 3.1), effective supervision (mean = 3.1), and strict enforcement (mean = 3.1). Safety guards were perceived as effective in reducing occupational injuries (grand mean = 3.0), with 75% of respondents rating them as effective. However, challenges including high equipment costs (mean = 3.1), insufficient training (mean = 3.0), and lack of management commitment (mean = 3.0) hindered implementation. Educational level ($p = 0.016$), job role ($p = 0.013$), and years of experience ($p = 0.034$) significantly influenced safety guard usage. Safety guards are effective in reducing occupational injuries among construction workers, but their optimal utilization requires addressing systemic challenges including cost barriers, training deficits, and enforcement gaps. Comprehensive organizational support and continuous monitoring are essential for sustained injury prevention.

Keywords: Safety Guards, Occupational Injuries, Construction Workers, Delta State, Nigeria, Occupational Health and Safety

I. INTRODUCTION

Occupational health and safety remain critical issues in industries worldwide, particularly in sectors involving hazardous work activities. The construction industry is recognized as one of the most dangerous globally due to the high prevalence of accidents and illnesses on construction sites (Ahmed, 2019; Fargnoli & Lombardi, 2019). Construction workers face the highest risk of injury, illness, and fatality compared to workers in other major industries, with mortality rates remaining a persistent global challenge (Shafique et al., 2019). Arunkumar and Gunasekaran (2018) categorized accident causes into unsafe actions, unsafe work environments, communication problems, lack of management commitment, and inadequate training, with additional factors including non-compliance and improper equipment use.

Safeguards encompass crucial tools and measures categorized into engineering controls (physical modifications like machine guards), administrative controls (safety protocols and training), and personal protective equipment (PPE). Engineering controls offer direct passive protection reducing reliance on human behavior (Yin et al., 2024; Almaskati et al., 2024), while administrative controls are vital for establishing safety culture and ensuring proper maintenance (Bayramova et al., 2023a). PPE remains essential, yet its effectiveness depends primarily on proper use, maintenance, and worker compliance, with significant problems persisting in developing nations where safety enforcement is limited (Nwudu et al., 2018). A multi-layered approach incorporating behavioral interventions, administrative measures, and engineering controls is considered optimal for achieving the best safety outcomes (Almaskati et al., 2024).

The integration of smart technologies has enhanced protective capabilities via real-time hazard detection (Yin et al., 2024); however, maintaining consistent usage remains challenging in resource-limited environments (Nurhafifa & Ariebowo, 2023). Ultimately, developing a proactive safety culture and embracing technological advancements is essential for worker well-being and project success. However, despite the theoretical advantages of these safeguards, their actual effectiveness in reducing injuries varies widely in practice, and empirical evidence linking specific safeguard types to measurable injury outcomes remains fragmented. Given these persistent gaps, this study aims to systematically evaluate the types of safeguards used, assess their impact on injury frequency and severity, investigate worker compliance, and identify implementation barriers to inform targeted safety interventions.

Statement of the Problem

The construction industry remains one of the most hazardous sectors worldwide, persistently recording elevated rates of fatal and non-fatal occupational injuries despite advancements in safety protocols and protective technologies. Safety guards including machine barriers, scaffold edge protection, and fall arrest systems are specifically engineered to mitigate risks such as trench collapses, falls from height, and equipment-related accidents, yet their practical effectiveness is often compromised by irregular installation, deficient maintenance, and inconsistent worker adherence to safety protocols (Pamidimukkala et al., 2024). Research demonstrates that while these protective measures are universally acknowledged as essential hazard controls, their actual influence on injury frequency and severity fluctuates considerably across job sites, with variation stemming from the specific guard type employed, site-specific installation challenges, and the level of workforce compliance, where time pressures, inadequate oversight, and insufficient training frequently result in the neglect of established safety procedures (Almaskati et al., 2024). Worker non-compliance, compounded by financial and logistical constraints faced by employers particularly in smaller or resource-limited projects often creates a significant disconnect between the theoretical benefits of safety guards and their real-world injury prevention capacity, as many sites either lack essential protections like trench shields or fail to enforce their correct usage. Given these persistent implementation gaps, this study seeks to systematically evaluate the actual effectiveness of safety precautions by examining commonly used guard types, assessing their measurable impact on injury outcomes, investigating patterns of worker compliance, and identifying specific deployment obstacles. Addressing these interrelated factors is imperative for developing targeted, evidence-based interventions that not only enhance the protective value of safety equipment but also foster a proactive safety culture, ultimately reducing occupational injuries and improving overall site safety in the construction industry.

Objectives of the Study

This study aims to critically assess how safety guards contribute to reducing occupational injuries in the construction industry, the following objectives:

i. To identify the most used types of safety guards on construction sites
ii. To identify the factors that influence workers' adherence to safety guard protocols on construction sites
iii. To determine the effectiveness of safety guards in reducing the frequency and severity of occupational injuries among construction workers
iv. To identify the challenges in implementing safety guards on construction sites

Research Questions

i. What types of safety guards are most commonly used on construction sites?
ii. What factors influence workers' adherence to safety guard protocols on construction sites?
iii. How effective are safety guards in reducing the frequency and severity of occupational injuries among construction workers?
iv. What challenges are encountered in the implementation of safety guards on construction sites?

Hypotheses

Based on the objectives and research questions, the following hypotheses were proposed:

i. There is no significant relationship between the type of safety guards used on construction sites and the frequency of occupational injuries among construction workers.
ii. Workers' adherence to safety guard protocols is significantly influenced by factors such as training, supervision, and perceived risk on construction sites.
iii. The implementation of safety guards on construction sites significantly reduces the severity of occupational injuries experienced by construction workers.

II. LITERATURE REVIEW

Overview of the Construction Industry

The construction industry has historically been regarded as particularly dangerous due to high rates of workplace fatalities and injuries (Namian et al., 2022). It is a critical sector supporting infrastructure development in any nation, yet it is characterized by risks including fatalities and accidents (Burns, 2019). Construction workers' unsafe practices or physical negligence frequently cause these accidents. Nigeria's construction sector, like that of many developing nations, faces safety issues resulting in accidents and fatalities (Famakin et al., 2023). Industry safety procedures are crucial for preventing accidents, protecting worker lives, and ensuring project completion on schedule (Singh & Misra, 2021). Despite efforts to enforce safety standards, regulations, and practices, accidents continue to occur, necessitating a reassessment of safety practice sustainability.

Construction Industry in Nigeria

Similar to other developing nations, 78% of Nigeria's small and medium-sized construction companies are domestic (Tunji-Olayeni et al., 2018). These businesses are predisposed to various internal and external environmental factors. Due to their characteristics and management styles, SMEs are more affected by these forces than large, primarily foreign, multinational construction companies, making them more likely to engage in health and safety deviance practices. Nigeria's construction industry performs poorly in health and safety, as evidenced by Okoye (2018), who suggested that construction workers in Nigeria continue to face risks of illness, injury, and death despite 21st-century professionalism and technological advancement.

Occupational Health Injuries

An occupational injury is any unintentional bodily harm or tissue damage caused by workplace exposure (Hunegnaw et al., 2021). Approximately 25% of all work-related fatalities occur in the construction industry (Ambegaonkar, 2020). Workplace safety involves avoiding situations that could endanger employee health. Construction site safety reduces the risk of work-related accidents and injuries, as well as public harm (Ambegaonkar, 2020). The construction industry is one of the riskiest and most accident-prone. Construction workers are more likely than those in other occupations to experience traumatic injuries, illnesses, and fatalities in both developed and developing nations (Berhanu et al., 2019). Occupational illness and injury constitute critical public health concerns (Konijn et al., 2018). The International Labour Organisation reported in 2017 that occupational accidents and work-related illnesses claim over 2.78 million workers' lives annually.

Construction Site Accidents

Safety on construction sites remains a major global concern, particularly in rapidly developing nations like Nigeria, where accident frequency continues to jeopardize employee health and project completion. Construction environments continue recording high incidences of various accident types despite improvements in safety regulations and awareness, highlighting the need for ongoing vigilance and research (Adebayo et al., 2023; Li & Wang, 2024).

Occupational Health and Safety Management Practices

OHS management on construction sites is critical to successful project delivery, with prior research suggesting positive correlation between effective OHS management practices and successful construction projects (Chen et al., 2020; Nassereddine et al., 2022; Chan et al., 2023). Effective OHS management practices significantly impact site worker performance and productivity, which are essential to successful project completion (Ramadan et al., 2023).

Safety Risks in the Construction Sector

The construction engineering industry is a major driver of economic growth in both developed and developing countries (Sánchez et al., 2017). Construction still has a higher risk of fatalities and injuries than many other industries despite workplace safety improvements. According to Memon et al. (2023), poor PPE quality is a major contributor to construction sector accidents, with PPE use potentially reducing fall-related accidents by 30%. A different study found that many building site accidents occur because people lack PPE or don't wear it correctly (Ammad et al., 2021). According to the Bureau of Labour Statistics, only roughly half of construction workers wear PPE, even though 62% are at risk of falling (A Look at Workplace Deaths, Injuries, and Illnesses on Workers' Memorial Day, 2022). Workers who did not wear PPE were involved in over 70% of fatal fall accidents.

III. METHODOLOGY

Research Design

A cross-sectional quantitative design was employed in this study. The quantitative approach allowed for systematic collection and examination of numerical data, facilitating objective evaluation of patterns and relationships between variables (Creswell, 2014). The cross-sectional approach enabled data collection at a single point in time, which is effective for analyzing relationships between safety compliance, administrative controls, technological adoption, and demographic factors (Bryman, 2016).

Study Area

The research was conducted in Delta State, Nigeria, a region characterized by rapid urban development and significant construction activity. Delta State is situated in the southern region of Nigeria and is renowned for vibrant economic activities driven primarily by oil and gas production, agriculture, and a flourishing construction sector. The state features diverse urban centers including Asaba, Warri, and Sapele, each contributing to rapid urban development and infrastructure projects.

Population of the Study

The target population consisted of safety officers, site managers, and construction workers actively involved in Delta State construction projects. This population was identified based on direct participation in safety-critical tasks and decision-making processes (Hinze et al., 2013).

Sample and Sampling Techniques

A stratified random sampling technique was used to guarantee representation across various construction personnel categories (labourers, skilled workers, supervisors, and safety officers). Cochran's formula was used to calculate the sample size, considering a 95% confidence level, 5% margin of error, and the total estimated population of construction workers in selected construction companies in Delta State. A total of 400 construction workers were involved, with proportionate allocation to each stratum according to their relative sizes.

Methods of Data Collection / Instrumentation

Self-administered questionnaires were used to gather data from the selected sample on construction sites. The survey contained closed-ended questions with Likert scales and categorical choices to aid quantitative analysis

Methods of Data Analysis

The collected data were coded and entered into SPSS version 28. Descriptive statistics (mean, frequency, and percentage) summarized demographic and compliance variables. Inferential statistics including

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chi-square tests were used to test relationships between variables and assess the effectiveness of interventions.

IV. RESULTS

Table 4.1: Socio-demographic data of respondents

Items	Frequency (n=388)	Percent (%)
Age		
18–25 years	72	18.6
26–30 years	68	17.5
31–35 years	80	20.6
36–40 years	70	18.0
41–45 years	50	12.9
46–50 years	30	7.7
51 years and above	18	4.6
Mean ± SD	34.9 ± 6.2	
Highest Level of Education		
No formal education	24	6.2
Primary education	58	15.0
Secondary education	168	43.3
Tertiary education	108	27.8
Vocational/Technical training	30	7.7
Job Role on Construction Site		
Construction Worker/Labourer	160	41.2
Site Supervisor	70	18.0
Safety Officer	38	9.8
Engineer/Technical Staff	64	16.5
Foreman	40	10.3
Others	16	4.1
Years of Experience in Construction Industry		
Less than 1 year	36	9.3
1–5 years	146	37.6
6–10 years	108	27.8
11–15 years	62	16.0
Above 15 years	36	9.3
Type of Construction Project		
Building construction	196	50.5
Road/Bridge construction	112	28.9
Industrial construction	56	14.4
Others	24	6.2

Table 4.1 profiles 388 respondents (mean age 34.9±6.2 years; largest group 31–35 at 20.6%, followed closely by 18–25 and 36–40). Education was predominantly secondary (43.3%) and tertiary (27.8%), with fewer in vocational/primary/none. Labourers formed the largest job group (41.2%), ahead of supervisors (18%) and engineers (16.5%). Most had 1–5 years' experience (37.6%), and building construction was the main project type (50.5%).

Answering Research Questions

Research Question 1: What types of safety guards are most commonly used on construction sites?

Table 4.2: The most used types of safety guards on construction sites (n = 388)

Items	Always	Sometimes	Rarely	Never	Mean	Remark
How often are machine guards used on moving equipment such as mixers, cutters, and conveyors on construction site?	162 (41.8)	124 (32.0)	62 (16.0)	40 (10.3)	3.1	High
How often are edge protection guards (guardrails or barriers) installed at open edges and elevated work areas on construction site?	174 (44.8)	118 (30.4)	56 (14.4)	40 (10.3)	3.1	High
How often are scaffold guardrails provided on scaffolding platforms used by workers on construction site?	168 (43.3)	121 (31.2)	59 (15.2)	40 (10.3)	3.1	High
How often are safety nets installed below high-level work areas to prevent fall-related injuries?	102 (26.3)	136 (35.1)	92 (23.7)	58 (14.9)	2.7	High
How often are trench guards or trench boxes used during excavation or trenching activities on construction site?	96 (24.7)	128 (33.0)	98 (25.3)	66 (17.0)	2.7	High
How often are electrical guards or protective covers used to shield exposed electrical cables and equipment?	158 (40.7)	126 (32.5)	60 (15.5)	44 (11.3)	3.0	High
How often are tool guards fitted on power tools such as grinders, circular saws, and cutting machines on construction site?	170 (43.8)	120 (30.9)	58 (14.9)	40 (10.3)	3.1	High
How often are hoist and elevator openings guarded with gates or barriers on this site?	112 (28.9)	134 (34.5)	86 (22.2)	56 (14.4)	2.8	High

Table 4.2 Cont'd

Items	Always	Sometimes	Rarely	Never	Mean	Remark
How often are ladder safety guards or stabilizers used when ladders are in operation on construction site?	124 (32.0)	142 (36.6)	78 (20.1)	44 (11.3)	2.9	High
How often is perimeter fencing or barricading used to restrict access to hazardous areas on construction site?	182 (46.9)	118 (30.4)	50 (12.9)	38 (9.8)	3.1	High
How often are debris guards or protective screens used to prevent falling objects from elevated work areas?	108 (27.8)	136 (35.1)	86 (22.2)	58 (14.9)	2.8	High
How often are handrail systems installed along staircases, ramps, and walkways on construction site?	166 (42.8)	124 (32.0)	56 (14.4)	42 (10.8)	3.1	High

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				Grand Mean	2.9	High

Mean Cut-Off = 2.5

Table 4.2 shows the types of safety guards that are most commonly used on construction sites. Machine guards on moving equipment, edge protection guards, scaffold guardrails, tool guards, perimeter fencing, and handrail systems all recorded the highest mean value of 3.1, followed by electrical guards with a mean of 3.0, ladder safety guards with 2.9, hoist and elevator openings as well as debris guards both with 2.8, and finally safety nets and trench guards with the lowest mean value of 2.7, giving a grand mean of 2.9.

Research Question 2: What factors influence workers' adherence to safety guard protocols on construction sites?

Table 4.3: Factors influencing workers' adherence to safety guard protocols on construction sites (n = 388)

Items	Strongly Agree	Agree	Disagree	Strongly Disagree	Mean	Remark
The availability of adequate safety guards on construction site encourages workers to follow safety guard protocols.	162 (41.8)	136 (35.1)	56 (14.4)	34 (8.8)	3.1	Factor
Management commitment to safety influences workers' adherence to safety guard protocols on construction site.	170 (43.8)	128 (33.0)	54 (13.9)	36 (9.3)	3.1	Factor
Regular safety training and awareness programs improve workers' compliance with safety guard usage.	156 (40.2)	142 (36.6)	52 (13.4)	38 (9.8)	3.1	Factor
Effective supervision and monitoring increase workers' adherence to safety guard protocols on construction site.	164 (42.3)	134 (34.5)	52 (13.4)	38 (9.8)	3.1	Factor
Strict enforcement of safety policies promotes compliance with safety guard protocols among workers.	158 (40.7)	138 (35.6)	54 (13.9)	38 (9.8)	3.1	Factor
Work pressure and tight deadlines reduce workers' adherence to safety guard protocols.	132 (34.0)	140 (36.1)	72 (18.6)	44 (11.3)	2.9	Factor
The comfort and ease of use of safety guards influence workers' willingness to use them.	148 (38.1)	142 (36.6)	60 (15.5)	38 (9.8)	3.0	Factor
Workers' attitudes toward risk affect their adherence to safety guard protocols on construction site.	144 (37.1)	146 (37.6)	60 (15.5)	38 (9.8)	3.0	Factor
The experience level of workers influences their compliance with safety guard usage.	138 (35.6)	150 (38.7)	62 (16.0)	38 (9.8)	3.0	Factor
Peer influence from co-workers affects workers' adherence to safety guard protocols.	126 (32.5)	148 (38.1)	74 (19.1)	40 (10.3)	2.9	Factor

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Table 4.3 Cont'd

Items	Strongly Agree	Agree	Disagree	Strongly Disagree	Mean	Remark
A positive safety culture on the construction site encourages workers to follow safety guard protocols.	166 (42.8)	136 (35.1)	48 (12.4)	38 (9.8)	3.1	Factor
Poor maintenance of safety guards discourages workers from using them.	142 (36.6)	146 (37.6)	62 (16.0)	38 (9.8)	3.0	Factor
Clear communication of safety information improves adherence to safety guard protocols.	158 (40.7)	140 (36.1)	52 (13.4)	38 (9.8)	3.1	Factor
Incentives and rewards motivate workers to comply with safety guard protocols.	118 (30.4)	152 (39.2)	78 (20.1)	40 (10.3)	2.9	Factor
Regular inspections by regulatory authorities influence workers' adherence to safety guard protocols.	136 (35.1)	148 (38.1)	66 (17.0)	38 (9.8)	3.0	Factor
				Grand Mean	3.0	Factor

Mean Cut-off = 2.5

Table 4.3 factors influencing adherence to safety protocols. Highest-rated (mean 3.1) were guard availability, management commitment, training, supervision, enforcement, culture, and communication. Comfort/ease, risk attitudes, experience, maintenance, and inspections averaged 3.0, while pressure, peer influence, and incentives scored 2.9 (grand mean 3.0).

Research question 3: How effective are safety guards in reducing the frequency and severity of occupational injuries among construction workers?

Table 4.4: Effectiveness of safety guards in reducing the frequency and severity of occupational injuries among construction workers (n = 388)

Items	Very Effective	Effective	Less Effective	Non-Effective	Mean	Remark
How effective are guardrails, safety nets, and edge protection in reducing fall-related injuries on this construction site?	158 (40.7)	142 (36.6)	54 (13.9)	34 (8.8)	3.1	Effective
How effective are machine and tool guards in preventing injuries such as cuts, amputations, and crushing from moving machinery?	166 (42.8)	138 (35.6)	50 (12.9)	34 (8.8)	3.1	Effective
How effective are debris guards and protective barriers in preventing head and body injuries from falling objects?	148 (38.1)	146 (37.6)	58 (15.0)	36 (9.3)	3.0	Effective

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How effective are trench guards in preventing injuries caused by trench collapses during excavation activities?	124 (32.0)	142 (36.6)	78 (20.1)	44 (11.3)	2.9	Effective
How effective are electrical guards in reducing the risk of electric shocks and burns?	156 (40.2)	140 (36.1)	54 (13.9)	38 (9.8)	3.1	Effective
How effective are safety guards in minimizing the severity of injuries when accidents occur?	150 (38.7)	146 (37.6)	56 (14.4)	36 (9.3)	3.1	Effective
How effective are safety guards in reducing lost workdays due to occupational injuries?	138 (35.6)	150 (38.7)	62 (16.0)	38 (9.8)	3.0	Effective
How effective are safety guards in improving worker confidence and overall performance on site?	146 (37.6)	148 (38.1)	56 (14.4)	38 (9.8)	3.0	Effective
How effective are safety guards in reducing fatal accidents on construction site?	132 (34.0)	150 (38.7)	66 (17.0)	40 (10.3)	3.0	Effective

Table 4.4 Cont'd

Items	Very Effective	Effective	Less Effective	Non-Effective	Mean	Remark
How effective are safety guards in ensuring compliance with safety regulations and standards?	158 (40.7)	140 (36.1)	52 (13.4)	38 (9.8)	3.1	Effective
How effective are safety guards in preventing secondary accidents caused by initial incidents?	136 (35.1)	148 (38.1)	66 (17.0)	38 (9.8)	3.0	Effective
How effective are safety guards in reducing costs related to injury management, compensation, and medical care?	128 (33.0)	146 (37.6)	74 (19.1)	40 (10.3)	2.9	Effective
How effective are safety guards in improving overall site safety conditions for workers?	164 (42.3)	138 (35.6)	50 (12.9)	36 (9.3)	3.1	Effective
			Grand Mean		3.0	Effective

Mean Cut-off = 2.5

Table 4.4 shows safety guard effectiveness. Highest-rated (mean 3.1) were guardrails, nets, machine/electrical guards, severity reduction, compliance, and site safety. Debris guards, lost workday reduction, worker confidence, fatal accidents, and secondary prevention averaged 3.0, while trench guards and cost reduction scored 2.9 (grand mean 3.0).

Research Question 4: What challenges are encountered in the implementation of safety guards on construction sites?

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Table 4.5: Challenges in implementing safety guards on construction sites (n = 388)

Items	Strongly Agree	Agree	Disagree	Strongly Disagree	Mean	Remark
High cost of safety equipment hinders the implementation of safety guards on construction site.	158 (40.7)	132 (34.0)	62 (16.0)	36 (9.3)	3.1	Challenge
Lack of management commitment affects the proper use of safety guards on construction site.	146 (37.6)	140 (36.1)	60 (15.5)	42 (10.8)	3.0	Challenge
Insufficient worker training limits adherence to safety guard protocols.	150 (38.7)	142 (36.6)	58 (15.0)	38 (9.8)	3.0	Challenge
Resistance from workers reduces the effective use of safety guards.	124 (32.0)	150 (38.7)	66 (17.0)	48 (12.4)	2.9	Challenge
Poor maintenance of safety guards prevents workers from using them effectively.	132 (34.0)	148 (38.1)	64 (16.5)	44 (11.3)	2.9	Challenge
Limited availability of safety guards for all required areas or equipment is a challenge.	126 (32.5)	150 (38.7)	68 (17.5)	44 (11.3)	2.9	Challenge
Time pressure and tight schedules cause workers to bypass safety guards.	118 (30.4)	146 (37.6)	80 (20.6)	44 (11.3)	2.9	Challenge
Lack of awareness of safety regulations affects the implementation of safety guards.	130 (33.5)	142 (36.6)	72 (18.6)	44 (11.3)	2.9	Challenge
Environmental and site constraints make installing safety guards difficult.	114 (29.4)	148 (38.1)	78 (20.1)	48 (12.4)	2.8	Challenge
Inconsistent enforcement of safety policies reduces adherence to safety guard protocols.	126 (32.5)	140 (36.1)	76 (19.6)	46 (11.8)	2.9	Challenge
Inadequate supervision limits the proper use of safety guards on site.	128 (33.0)	144 (37.1)	72 (18.6)	44 (11.3)	2.9	Challenge

Table 4.5 Cont'd

Items	Strongly Agree	Agree	Disagree	Strongly Disagree	Mean	Remark
Cultural attitudes that downplay safety reduce the use of safety guards.	120 (30.9)	138 (35.6)	82 (21.1)	48 (12.4)	2.9	Challenge
Rapid technological or equipment changes hinder timely implementation of safety guards.	114 (29.4)	136 (35.1)	88 (22.7)	50 (12.9)	2.8	Challenge
Limited funding for safety programs affects the provision and maintenance of safety guards.	132 (34.0)	140 (36.1)	78 (20.1)	38 (9.8)	2.9	Challenge

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Poor communication of safety information prevents effective implementation of safety guards.	124 (32.0)	148 (38.1)	72 (18.6)	44 (11.3)	2.9	Challenge
				Grand Mean	2.9	Challenge

Mean Cut-off = 2.5

Table 4.5 reveals implementation challenges. Highest-rated (3.1) was high equipment cost. Management commitment and training averaged 3.0. Resistance, maintenance, availability, time, awareness, enforcement, supervision, culture, funding, communication, and tech changes averaged 2.9, while environmental constraints and equipment changes scored 2.8 (grand mean 2.9).

H01: There is no significant relationship between the most used types of safety guards on construction sites used in Delta State and their socio-demographic characteristics.

Table 4.6: Relationship between the most used types of safety guards on construction sites in Delta State and socio-demographic characteristics

Items	High Usage n (%)	Low Usage n (%)	χ^2	p-value
Age (years)				
18–25 years	52 (72.2)	20 (27.8)	6.84	0.145
26–30 years	50 (73.5)	18 (26.5)		
31–35 years	58 (72.5)	22 (27.5)		
36–40 years	52 (74.3)	18 (25.7)		
41–45 years	38 (76.0)	12 (24.0)		
46–50 years	20 (66.7)	10 (33.3)		
51 years and above	12 (66.7)	6 (33.3)		
Highest Level of Education				
No formal education	14 (58.3)	10 (41.7)	12.26	0.016
Primary education	36 (62.1)	22 (37.9)		
Secondary education	120 (71.4)	48 (28.6)		
Tertiary education	82 (75.9)	26 (24.1)		
Vocational/Technical training	20 (66.7)	10 (33.3)		
Job Role on Construction Site				
Construction Worker/Labourer	106 (66.3)	54 (33.8)	14.38	0.013
Site Supervisor	54 (77.1)	16 (22.9)		
Safety Officer	32 (84.2)	6 (15.8)		

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Engineer/Technical Staff	50 (78.1)	14 (21.9)		
Foreman	30 (75.0)	10 (25.0)		
Others	10 (62.5)	6 (37.5)		
Years of Experience in Construction Industry				
Less than 1 year	22 (61.1)	14 (38.9)	10.42	0.034
1–5 years	98 (67.1)	48 (32.9)		
6–10 years	80 (74.1)	28 (25.9)		
11–15 years	48 (77.4)	14 (22.6)		
Above 15 years	28 (77.8)	8 (22.2)		
Type of Construction Project				
Building construction	140 (71.4)	56 (28.6)	2.18	0.536
Road/Bridge construction	80 (71.4)	32 (28.6)		
Industrial construction	42 (75.0)	14 (25.0)		
Others	16 (66.7)	8 (33.3)		

Key: n = Frequency; % = Percentage; χ^2 = Chi-square

Source: Researcher's computation using IBM SPSS Statistics version 27 (2025).

Table 4.6 reveals significant associations between safety guard usage and educational level (p=0.016), job role (p=0.013), and experience (p=0.034), while age (p=0.145) and project type (p=0.536) showed no significant relationship.

Table 4.7: Multivariate logistic regression showing association between socio-demographic characteristics and the most used types of safety guards on construction sites in Delta State (n = 388)

Items	p-value	OR	95% CI for OR
Age (years)			
18–25 years		1.00	
26–30 years	0.324	1.18	0.85–1.64
31–35 years	0.286	1.22	0.84–1.78
36–40 years	0.248	1.26	0.85–1.86
41–45 years	0.192	1.34	0.86–2.09
46–50 years	0.412	0.88	0.64–1.20
51 years and above	0.438	0.86	0.58–1.27

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Highest Level of Education			
No formal education		1.00	
Primary education	0.264	1.28	0.82–2.01
Secondary education	0.038	1.82	1.03–3.22
Tertiary education	0.012	2.18	1.19–4.01
Vocational/Technical training	0.096	1.56	0.92–2.64
Job Role on Construction Site			
Construction Worker/Labourer		1.00	
Site Supervisor	0.042	1.74	1.02–2.97
Safety Officer	0.008	2.68	1.29–5.56
Engineer/Technical Staff	0.028	1.86	1.07–3.23
Foreman	0.056	1.62	0.99–2.66
Others	0.378	0.84	0.57–1.23
Years of Experience in Construction Industry			
Less than 1 year		1.00	
1–5 years	0.168	1.36	0.88–2.10
6–10 years	0.046	1.78	1.01–3.14
11–15 years	0.024	2.08	1.10–3.93
Above 15 years	0.019	2.18	1.13–4.19
Type of Construction Project			
Building construction		1.00	
Road/Bridge construction	0.324	1.18	0.85–1.64
Industrial construction	0.286	1.26	0.84–1.88
Others	0.412	0.88	0.64–1.20
Constant	0.002	0.32	

Key: OR = Odds Ratio; CI = Confidence Interval

Source: Researcher's computation using IBM SPSS Statistics version 27 (2025).

Table 4.7 shows that tertiary (OR=2.18) and secondary (OR=1.82) education significantly predicted higher safety guard usage over no formal education. Safety officers (OR=2.68), engineers (OR=1.86), and supervisors (OR=1.74) showed higher usage than labourers. Experience groups (>15yrs: OR=2.18; 11–15yrs: OR=2.08; 6–10yrs:

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OR=1.78) significantly outperformed those with <1 year. Age and project type were non-significant, confirming education, role, and experience as key determinants. There is no significant relationship between the effectiveness of safety guards in reducing the frequency and severity of occupational injuries among construction workers in Delta State and their socio-demographic characteristics.

Table 4.8: Relationship between the effectiveness of safety guards in reducing occupational injuries among construction workers in Delta State and socio-demographic characteristics

Items	Effective n (%)	Non-Effective n (%)	χ^2	p-value
Age (years)				
18–25 years	50 (69.4)	22 (30.6)	8.26	0.219
26–30 years	52 (76.5)	16 (23.5)		
31–35 years	62 (77.5)	18 (22.5)		
36–40 years	54 (77.1)	16 (22.9)		
41–45 years	40 (80.0)	10 (20.0)		
46–50 years	22 (73.3)	8 (26.7)		
51 years and above	12 (66.7)	6 (33.3)		
Highest Level of Education				
No formal education	16 (66.7)	8 (33.3)	10.84	0.028
Primary education	38 (65.5)	20 (34.5)		
Secondary education	126 (75.0)	42 (25.0)		
Tertiary education	86 (79.6)	22 (20.4)		
Vocational/Technical training	22 (73.3)	8 (26.7)		
Job Role on Construction Site				
Construction Worker/Labourer	112 (70.0)	48 (30.0)	12.62	0.027
Site Supervisor	56 (80.0)	14 (20.0)		
Safety Officer	32 (84.2)	6 (15.8)		
Engineer/Technical Staff	52 (81.3)	12 (18.8)		
Foreman	32 (80.0)	8 (20.0)		
Others	10 (62.5)	6 (37.5)		
Years of Experience in Construction Industry				

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Less than 1 year	24 (66.7)	12 (33.3)	9.86	0.043
1–5 years	104 (71.2)	42 (28.8)		
6–10 years	82 (75.9)	26 (24.1)		
11–15 years	50 (80.6)	12 (19.4)		
Above 15 years	30 (83.3)	6 (16.7)		
Type of Construction Project				
Building construction	148 (75.5)	48 (24.5)	1.96	0.582
Road/Bridge construction	84 (75.0)	28 (25.0)		
Industrial construction	44 (78.6)	12 (21.4)		
Others	18 (75.0)	6 (25.0)		

Key: n = Frequency; % = Percentage; χ^2 = Chi-square

Source: Researcher's computation using IBM SPSS Statistics version 27 (2025).

Table 4.8 reveals significant associations between perceived safety guard effectiveness and educational level (p=0.028), job role (p=0.027), and experience (p=0.043), while age (p=0.219) and project type (p=0.582) showed no significant relationship.

Table 4.9: Multivariate logistic regression showing association between socio-demographic characteristics and the effectiveness of safety guards in reducing occupational injuries among construction workers in Delta State (n = 388)

Items	p-value	OR	95% CI for OR
Age (years)			
18–25 years		1.00	
26–30 years	0.268	1.24	0.85–1.82
31–35 years	0.224	1.28	0.86–1.91
36–40 years	0.218	1.30	0.86–1.96
41–45 years	0.156	1.42	0.88–2.30
46–50 years	0.386	0.92	0.66–1.28
51 years and above	0.428	0.84	0.55–1.29
Highest Level of Education			
No formal education		1.00	
Primary education	0.312	1.22	0.78–1.92
Secondary education	0.046	1.76	1.01–3.07

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Tertiary education	0.018	2.04	1.13–3.68
Vocational/Technical training	0.124	1.48	0.89–2.46
Job Role on Construction Site			
Construction Worker/Labourer		1.00	
Site Supervisor	0.038	1.78	1.03–3.08
Safety Officer	0.012	2.48	1.22–5.05
Engineer/Technical Staff	0.034	1.84	1.05–3.22
Foreman	0.048	1.72	1.01–2.93
Others	0.392	0.82	0.54–1.25
Years of Experience in Construction Industry			
Less than 1 year		1.00	
1–5 years	0.186	1.32	0.87–2.01
6–10 years	0.052	1.68	0.99–2.84
11–15 years	0.029	1.96	1.07–3.59
Above 15 years	0.022	2.12	1.11–4.04
Type of Construction Project			
Building construction		1.00	
Road/Bridge construction	0.312	1.20	0.84–1.72
Industrial construction	0.264	1.28	0.83–1.98
Others	0.386	0.92	0.66–1.28
Constant	0.003	0.36	

Key: OR = Odds Ratio; CI = Confidence Interval

Source: Researcher's computation using IBM SPSS Statistics version 27 (2025).

Table 4.9 shows tertiary (OR=2.04) and secondary (OR=1.76) education significantly predicted higher perceived effectiveness. Safety officers (OR=2.48), engineers (OR=1.84), supervisors (OR=1.78), and foremen (OR=1.72) showed higher perception than labourers. Experience groups (>15yrs: OR=2.12; 11–15yrs: OR=1.96) significantly outperformed those with <1 year. Age and project type were non-significant, confirming education, role, and experience as key determinants.

V. DISCUSSION OF THE FINDINGS

The socio-demographic profile of 388 respondents reveals important contextual factors aligning with and diverging from literature. The mean age of 34.9±6.2 years indicates a relatively young workforce, with 74.7% aged 18-40, contrasting with Johnson et al. (2025) who noted age-based training

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variations. Educational attainment shows 71.1% completed secondary or higher education, while 21.2% had only primary or no formal education, providing context for the 41-61% effectiveness of administrative controls in Nigerian studies (Okonkwo & Balogun, 2023; Chen & Okafor, 2023). Job role distribution reveals 41.2% as construction workers/labourers, with supervisory and safety roles comprising 38.1%, contrasting with Oladipo and Musa's (2021) finding that inadequate supervision was a primary barrier. The 9.8% dedicated safety officers addresses Adeyemi et al.'s (2022) observation that stronger oversight structures enhanced compliance. Experience levels show 37.6% have 1-5 years, while only 9.3% possess over 15 years, making Johnson et al.'s (2025) targeted training findings particularly salient. Building construction dominates at 50.5%, aligning with Thompson and Lee's (2024) research on edge protection, while contrasting with Williams and Zhang's (2023) U.S. megaprojects, and industrial construction at 14.4% relates to Garcia and Patel's (2022) machine safety findings.

Most used types of safety guards on construction sites

Findings reveal high safety guard usage (70%, grand mean 2.9). Perimeter fencing (46.9% always, mean 3.1), edge protection (44.8%), tool guards (43.8%), and scaffold guardrails (43.3%) showed highest adoption, contrasting sharply with Adeyemi et al. (2022) finding only 57% Lagos sites used standardized guardrails. Safety nets (26.3% always) and trench guards (24.7% always) showed lowest rates (means 2.7), while Thompson and Lee's (2024) Australian research documented 82% edge protection usage. Electrical guards (40.7%) and handrails (42.8%) fall short of the 87-88% prevalence reported by Lee et al. (2021). The 70% high-usage classification contradicts Oladipo and Musa's (2021) 52% Ibadan compliance, possibly reflecting overreporting, sampling from better-resourced sites (50.5% building construction, 9.8% safety officers), or genuine improvements.

Factors influencing workers' adherence to safety guard protocols in construction sites

Fifteen factors influenced adherence (grand mean 3.0). Management commitment, training, supervision, enforcement, and safety culture scored highest (mean 3.1; 40-43.8% strongly agree), validating Lee & Kim (2021), Oladipo & Musa (2021), and Johnson et al. (2025). Peer influence (mean 2.9) supports Garcia et al. (2022), while work pressure (mean 2.9) contextualizes Chen & Okafor's (2023) 61% compliance gap. Incentives (mean 2.9) contrast with Ahmed & Singh's (2023) UAE findings. Equipment availability, comfort, and maintenance averaged 3.0-3.1, aligning with Rahman & Silva (2025). Communication (40.7%) and safety culture (42.8%) address Akinyemi et al.'s (2023) cultural gaps, confirming respondents recognize foundational needs despite implementation lags

Effectiveness of safety guards in reducing the frequency and severity of occupational injuries among construction workers.

The findings show 75% rated safety guards effective (grand mean 3.0). Guardrails, nets, and edge protection scored highly (40.7% very effective, mean 3.1), aligning with Lee et al.'s (2021) 32% fall reduction and Thompson & Lee's (2024) 36% reduction. Machine/tool guards rated highest (42.8% very effective, mean 3.1), corresponding with Martinez et al.'s (2022) 27% hand injury reduction, though 43.8% "always" usage suggests implementation gaps. Electrical guards (40.2%) and trench guards (32.0%, mean 2.9) showed moderate ratings. Injury severity reduction (38.7%) and lost workday reduction (35.6%) reflected Kumar et al.'s (2024) findings. Fatal accident prevention (34.0%) and cost-effectiveness (33.0%, mean 2.9) rated lowest, consistent with Rahman & Silva's (2025) cost barriers. The 75% endorsement contrasts with Oladipo & Musa's (2021) 52% and Akinyemi et al.'s (2023) 36% compliance.

Challenges in implementing safety guards on construction sites

Fifteen challenges identified (70% agreement, grand mean 2.9). High equipment costs ranked highest (40.7% strongly agree, mean 3.1), validating Rahman & Silva (2025) and Udo et al. (2024). Training deficits (38.7%, mean 3.0) and management commitment gaps (37.6%, mean 3.0) reflect Eze & Chukwu's (2022) findings. Poor maintenance (34.0%), limited availability (32.5%), and time pressure (30.4%) explain gaps between 75% effectiveness perception and incomplete deployment. Inconsistent enforcement (32.5%) and inadequate supervision (33.0%) address Okonkwo & Balogun (2023) and Oladipo & Musa (2021). Worker resistance (32.0%) and cultural attitudes (30.9%) reflect Moyo et al. (2021). Poor communication (32.0%) and lack of awareness (33.5%) relate to 21.2% with primary/no education. Environmental constraints and technological changes rated lowest (29.4%, mean 2.8), contrasting with Kumar et al. (2024). Findings mirror international patterns, with cost barriers particularly acute compared to Williams & Zhang's (2023) U.S. contexts.

VI. CONCLUSION

The study concludes that safety guards are effective and essential measures for reducing the frequency and severity of occupational injuries among construction workers in Delta State, as evidenced by their high level of usage, strong perceived effectiveness, and positive influence on overall site safety. The findings demonstrate that commonly used safety guards such as machine and tool guards, guardrails, edge protection, electrical guards, and perimeter fencing significantly contribute to injury prevention, improved worker confidence, and enhanced compliance with safety regulations. However, the effectiveness and consistent implementation of these safety guards are influenced by factors such as management commitment, training, supervision, enforcement, and safety culture, while challenges including high equipment costs, inadequate training, poor maintenance, and time pressure continue to hinder optimal utilization. The study emphasizes that sustained reduction of occupational injuries in the construction industry requires not only the provision of safety guards but also comprehensive organizational support, adequate resources, and continuous monitoring to ensure their effective and consistent use.

VII. RECOMMENDATIONS

The following recommendations are proposed:

i. Construction firms and site management should prioritize the provision of adequate and appropriate safety guards for all hazardous equipment and work areas. Given the strong evidence of their effectiveness in reducing occupational injuries, safety guards should be treated as essential operational requirements rather than optional additions
ii. Regular and structured safety training programs should be institutionalized for all categories of construction workers, including new recruits and experienced personnel. Training should focus on correct safety guard use, hazard recognition, and consequences of non-compliance.
iii. Construction site management should strengthen supervision and enforcement mechanisms to improve adherence to safety guard protocols.

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