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Safety Risk Assessment of Building Construction Work Items in Abuja

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Work-related injuries pose major public health and development challenges, with serious health, social, and economic consequences for workers and their employers. The study's aim is to assess the level of safety risk associated with building construction work items in Abuja. Purposive sampling technique was adopted for data collection. The mean score method was used to analyse the most hazardous work items in building construction projects, result revealed that lift installation, electrical work, roof work, and steel structure, with mean scores of 4.03, 4.00, 3.40, and 3.80, respectively were the riskiest work items. The risk prioritization number were used to analyse safety risk assessment, result revealed that the highest medium risk level was installation of electrical work, roof work, and installation of lift, with average risk scores of 11.48, 11.01, and 10.74, respectively. It was concluded that most building construction activities in Abuja are deemed to be of medium risk; nonetheless, employees are still at risk of injury and accidents on sites that are tolerable. It is recommended that all construction safety plans include an acceptable risk assessment technique, with proper risk identification and prioritization being a requirement for effective risk management and control. It is expected that stakeholder understanding of the construction sector will extend in terms of identifying work items with high or low severity or frequency of risk, hence improving construction safety.

Keywords: Building, Construction, Risk Assessment, Safety, Work item
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INTRODUCTION

The nature of building projects has exposed workers to multiple dangers and safety risks, potentially leading to a high rate of occupational mishaps, injury, and death on job sites (Abas *et al*., 2020). Workers on construction sites engage in a wide range of activities, each of which comes with its own set of risks. As a result, they are exposed to dangers such as physical, psychological, biological, and chemical dangers (Mersha *et al*., 2017). According to the Census of Fatal Occupational Injuries (CFOI, 2017), a variety of factors can put construction workers at risk for occupational injury due to multiple operatives' activities on construction sites that can lead to injuries and death, such as constructing, assembling, dismantling, and repairing. Because of the labour-intensive nature of the construction process, it has a significant level of risk. At the same time, occupational accidents cost the construction sector a lot of money. Occupational accidents cause major social and economic problems for workers as a result of bodily injuries and death.

According to the International Labour Organization (ILO, 2012) the construction industry accounts for 25 to 40 percent of all occupational fatalities worldwide. According to the ILO, 60,000 fatal occurrences occur yearly on construction sites worldwide, and a worker dies in an occupational accident every 10 minutes (Park *et al.*, 2020). According to a 2016 report from the Bureau of Labour Statistics

(BLS), the construction business had a mortality rate of 10.1 fatalities per 100,000 workers, which was higher than other industries such as forestry (0.91), transportation (0.75), and fishing (0.24 deaths per 100,000 workers). In 2016, the construction industry was responsible for 19 percent of all industrial deaths in the United States, and it was also discovered to have a higher fatality rate than other industries around the world (Chan *et al.*, 2018). According to the Health and Safety Executive (2017), the construction industry in the United Kingdom has a death rate of 1.37 fatalities per 100,000 workers, which is more than three times higher than the national average. The yearly occupational fatality rate in Nigeria, according to Hamalainen *et al.* (2009), is 24 fatalities per 100,000 employees. The situation in developing countries like Nigeria is much worse than it is in developed countries like the United States. Abubakar *et al.* (2015) further revealed that work-related fatalities are on the increase in Nigeria.

Work-related injuries pose major public health and development challenges, with serious health, social, and economic consequences for workers and their employers (Tolera, 2016). In the developing nations safety issues receive inadequate attention and provision, this is owing to cost, lack of enforcement of health and safety rules and ignorance of the stakeholders (Idoro, 2011; Windapo, 2014). Windapo (2014) further asserted that the risks associated with construction activities that have the greatest potential for causing injuries on site are being overlooked. The aim of the study is to assess the safety risk level associated with specific work items in Abuja construction projects. The study's objective is to determine the most hazardous work items and to conduct a risk assessment on work items in building construction projects.

LITERATURE REVIEW

Risk is defined as a potential event that results in an outcome that is different from what is planned (Hallowell *et al.,* 2017). Hughes and Ferret (2016) described risk assessment as a method used to decide on the priorities and set objectives for eliminating hazards and reducing risks. Safety risk is considered to be the likelihood of an injury or illness of a given level of severity (Baradan & Usmen, 2006; Hughes & Ferret, 2016). Probability is defined as the likelihood or rate of occurrence of an accident or hazards in a specific period of time (Hallowell *et al.*,2011). Severity defines the magnitude of the outcome of an accident or hazards. Severity may be described in terms of numerically in terms of money impact to the organisation or firm or in terms of degree of injury such as medical case, lost work-time, fatality (Hallowell *et al*., 2017). Safety risk have consistently been calculated by several researchers using equation (1), which express the quantity of safety risk as the product frequency of injury and severity (Jannadi & Almishari, 2003; Baradan & Usmen, 2006; Hughes & Ferret, 2016)

Risk value is expressed as:

$$R = P \text{ X } S \quad (1)$$

Where: P = Likelihood of occurrence

S = severity of harm

There are two basic forms of qualitative risk assessment and quantitative risk assessment (Hughes & Ferret, 2016). The qualitative risk assessment is based on individual judgement and typically classified as low, medium or high. This is used to determine the time frame in which further action is to be taken. A quantitative risk assessment quantifies risk level in terms of the likelihood of risk occurring to the probable severity of the consequence and assigning a numerical value to the risk. The risk matrix is a table that comprises several categories of Severity (consequence) on one axis and probability (likelihood) on the other axis (Zolfagharian *et al*., 2014). The risk value is calculated by multiplying the probability (likelihood) of occurrence (P) and the potential severity of hazardous event (S) as shown in Table 1.

Table 1: Risk Matrix for severity and probability showing numeric rating

Likelihood / Severity	Rare (1)	Remote (2)	Occasional (3)	Frequent (4)	Almost certain (5)
Catastrophic (5)	5	10	15	20	25
Major (4)	4	8	12	16	20
Moderate (3)	3	6	9	12	16
Minor (2)	2	4	6	8	10
Negligence (1)	1	2	3	4	5

Source: Workplace Safety and Health Council (2011)

Numerous studies have identified health and safety risks on construction sites; some studies have associated certain building trades/activities to a high risk of fatality or injury, while others have associated them to a low risk. Jannadi and Almishari (2003) developed a Risk Assessor Model (RAM) software for calculating the probability of accident and established semi-quantitative scales to measure the severity of consequences, probability of occurrence. Baradan and Usmen (2006) conducted a study on occupational injury and fatality risk analysis on 16 building trades and discovered that ironworkers, roofers, electricians, brick mason, block mason and stone mason and painters and paperhangers were the riskiest building trades. Fung *et al*. (2010) developed a model that identified the major types of work trades, accidents, and causes of accidents; the results revealed that steel fixer and carpenter were the highest risk trades.

Hallowell and Gambatese (2009) evaluated the severity of consequences and probability of occurrence in semi-quantitative terms and proposed an activity based total risk quantification of concrete formwork. Memarian and Mitropoulos (2013) studied accidents in masonry construction and identified the most frequent incident was overexertion, struck by object and contact with objects. Gurcanli *et al.* (2015) studied an activity-based risk assessment and safety cost estimation for residential building construction projects. Findings revealed that reinforced concrete work, excavation, and electrical work, were the most dangerous operations in a building project. Williams *et al.* (2017) studied the cases and causes of fatal building construction accidents discovered that fall from height, struck-by, electrocution, drowning were the fatal accidents on construction sites. Okoye (2018) investigated occupational health and safety risk levels of building construction trades in Nigeria and identified carpentry (formwork and roof) masonry (block laying, brick laying and plastering) iron bending, steel fixing and tiling work and painting as trade associated with high risks. Ghousi *et al.* (2018) designed a flexible method of building construction safety risk assessment and identified structural steel, excavation and building facade as the riskiest building trades in building construction projects.

RESEARCH METHODOLOGY

Quantitative methodology was adopted for the study whereby questionnaire survey was used as the data collection method. Collis and Hussey (2003) described survey as a positivistic paradigm that draws a sample from a larger population in order to draw a conclusion about the population. A well-structured questionnaire was developed and administered to seek the opinion of construction professionals such as Project Managers, Quantity Surveyors, site Engineers, Health and Safety Managers who managed and supervised construction projects in Abuja to assess their perception with a view to determining the safety risk level of the various work activities in building construction projects. Purposive sampling technique was adopted for the collection of data for the study. Purposive sampling technique is described as a nonprobability method used in choosing cases for a study based on the judgement of the researcher for the appropriate cases, such as selecting a variety of types of cases for in-depth investigation (Blaikie, 2010). The choice of purposive sampling technique hinged on its ability to provide a representative sample of the sampled elements based on certain specified criteria, such as the possession of precise knowledge required by the study (Patton, 2001). Respondents sampled were those who were accessible and willing to participate in addition where having on-going building projects or projects that were completed within three years. This was because the questions in the questionnaire were based on building construction project and required experienced and knowledgeable respondents. Building construction project was the unit of analysis.

Method of Data Collection

The questionnaire was designed to determine the most hazardous work activities and to assess the safety risk level of the various work items in building construction projects in Abuja. The questionnaire comprised of two sections. The first section captured information on the respondent's background which include: Academic qualification and year of experience. The second section of the questionnaire focused on the most hazardous work activities and safety risk level of the various work activities. Seventeen (17) common work activities for building construction projects were identified from literature reviewed (Jannadi & Almishari, 2003; Baraban & Usmen, 2006; Memarian & Mitropoulos, 2013; Choi, 2015; Gurcanli *et al.*, 2015; Bilir & Gurcanli, 2018; Okoye, 2018, Ghousi *et* al., 2018).

Respondent were requested to express their view, based on their wealth of experience on the most hazardous work activities and on their perception on the severity of risk impact and probability of occurrence on the identified work activities. Using a Likert scale of 1 to 5 where: 1- Very Low risk, 2- Low risk, 3- moderate risk, 4-High Risk, 5- Very High risk for the most hazardous work activities. For Severity of risk (consequence of impact) (1) = Negligible, (2) = Minor, (3) = Moderate, (4) = Major, (5) = Catastrophic and Likelihood of risk occurrence (probability of occurrence) (1) = Rare, (2) =Remote, (3) =Occasional, (4) = Frequent, (5) = Almost.

Data Analysis

Descriptive statistics was employed for data analysis, which involved the use of mean score and risk prioritization number. The mean score (MS) was used to rank the response items according to the central tendency of responses, as represented in equation (2)

$$MS = \frac{1n_1+2n_2+3n_3+4n_4+5n_5}{n_1+n_2+n_3+n_4+n_5} \quad (2)$$

A quantitative risk analysis was carried out to assess the severity and probability for each work item in building construction projects. The 5x5 matrix defines 5 classes of likelihood and severity as shown in Table 2. The probability and severity risk impact of hazard that may cause injury or ill-health and were rated in order of 1-5 score.

Table 2: Categories for Severity and Probability risk impact

Severity	Description	Level	Probability	Description
Catastrophic	Fatality, fatal diseases or multiple major injuries	5	Almost	Certain continual or repeating experience.
Major	Serious injuries or life-threatening occupational disease (includes amputations, major fractures, multiple injuries, occupational cancer, acute poisoning).	4	Frequent	Common occurrence.
Moderate	Injury requiring medical treatment or ill-health leading to disability (includes lacerations, burns, sprains, minor fractures, dermatitis, deafness, work related upper limb disorders).	3	Occasional	Possible or known to occur.
Minor	Injury or ill-health requiring first-aid only (includes minor cuts and bruises, irritation, ill-health with temporary discomfort).	2	Remote	Not likely to occur under normal circumstances.
Negligible	Not likely to cause injury or ill-health	1	Rare	Not expected to occur but still possible.

Source: Workplace Safety and Health Council (2011)

Risk Categorization on the Basis of Risk Level

Risk prioritization number is use to obtain the degree of risk score, which invariably determines the level of risk which are attained by multiplying the severity and probability columns (Workplace Safety and Health Council 2011). This is computed using equation (3):

$$R = \frac{\sum PRO}{N} \times \frac{\sum SRI}{N}$$

Where PRO= Probability, SR= Severity (consequence) of risk impact and N= Number of items.

The rating of risk will require rating the risk as high, medium or low, depending on the likelihood of an activity to cause harm and how serious the harm might be (Workplace Safety and Health Council 2011). Table 3 summarises the risk rating or degree of risk and associated description of risk level.

Table 3: Risk Prioritization number and Risk Level of an Activity

Risk score scale	Risk level	Risk Acceptability
$1 \leq X \leq 4$	Low	Acceptable
$4 < X \leq 12$	Medium	Tolerable
$12 < X \leq 25$	High	Not acceptable

Source: Workplace Safety and Health Council (2011)

Where x= the actual risk score for the considering variable (work activities)

RESULTS AND DISCUSSION

Response Rate to Questionnaire

In this study 96 questionnaires were distributed to respondents and 40 were returned representing a response rate of 41.67%.

Analysis of Respondents' Profile

This section reveals the respondents' profile by examining their professional qualification and years of experience. Data collected in this regard is presented in Table 4.

Table 4 shows the educational qualification of the respondents, result revealed that HND/B.SC/ B. TECH were the largest group of the respondent representing 25(62.5%) of the respondents, 8(20%) had MSC/MTECH. 3(7.5%) had other qualifications not stated. 2 making 5% of the respondents were OND and PhD respectively. This indicates that the respondents are well knowledgeable and competent to provide appropriate data for the study. On working experience of the respondents, the highest score of respondents were those that had worked for 5-9years representing 13(32.5%) next were 10-14years representing 11(27.5%) of the sampled population. Third were 20years and above representing 6(15%), the least in the chart were 15-19 and less than 5years representing 5(12.5%). With the outcome of the result it would be concluded that the respondents could be considered knowledgeable

Table 4: Respondent's Educational Qualification and Working Experience

Parameter	Frequency	Percent (%)	Cumulative percent
Qualification			
OND	2	5.0	5.0
HND/BSC/BTECH	25	62.5	67.5
MSC/MTECH	8	20.0	87.5
PhD	2	5.0	92.5
Others	3	7.5	100.0
Total	40	100.0	
Working Experience			
<5 years	5	12.5	12.5
5-9 years	13	32.5	45.0
10-14 years	11	27.5	72.5
15-19 years	5	12.5	85.0
20 years and above	6	15.0	100.0
Total	40	100.0	

Determination of Most Hazardous Work Items in Building Construction Projects

This section presents the result of the most hazardous work items in building construction, the result is presented in table 5.

Table 5 shows the summary of the top ten most hazardous work items in building construction project. lift installation was ranked first as the riskiest work activity with mean score of 4.03. Second was electrical works with mean score of 4.00. Third was roof work with mean score of 3.4. Fourth was steel structure with mean score of 3.80. Fifth was cladding works with mean score of 3.33. The least was landscaping works with mean score of 2.23.

Table 5: Top Ten Most Hazardous Work Items of Building Construction Projects

S/N	Work Item in Building Construction Projects	Mean Score	Standard Deviation	Rank
1	Lift installation	4.03	0.79	1
2	Installation of electrical works	4.00	1.15	2
3	Roof work	3.95	0.82	3
4	Steel structure	3.80	1.07	4
5	Cladding work	3.33	1.06	5
6	Reinforced concrete work	3.33	0.93	6
7	Masonry	3.05	0.99	7
8	Frameworks	3.15	0.81	8
9	Excavation	3.14	1.02	9
10	Mechanical works	3.05	1.23	10

Risk Assessment of Work Items in Building Construction Projects

This section presents the result of the analysis of consequence of risk impact, probability of occurrence and risk assessment. The results are presented in table 6 - 7.

Table 6 shows the risk level of work items in building construction project. Result revealed that among the seventeen (17) work items in building construction project, the five most impactful risky work activities in building construction project were electrical work, installation of lift, steel structure, roof work and mechanical with Severity Risk Impact (SRI) score of 3.79, 3.78, 3.63, 3.41 and 3.05 respectively. Similarly, the five most occurring risky work activities in building construction project were roof work, electrical work, steel structure, installation of lift and reinforced concrete work with probability of occurrence (PRO) score of 3.23, 3.03, 2.95, 2.84 and 2.79 respectively.

Table 6: Level of Severity and Probability in Building Construction work items

Work Items.	Severity	Impact Level	Rank	Likelihood	Probability of Occurrence	Rank
Finishing in ceiling	2.53	Minor	11	2.42	Remote	11
Cladding work	2.95	Minor	6	2.54	Remote	7
Doors and Windows	2.22	Minor	16	2.19	Remote	14
Installation of electrical work	3.79	Moderate	1	3.03	Occasional	2
Excavation	2.88	Minor	8	2.53	Remote	8
External Works	2.56	Minor	10	2.50	Remote	9
Finishing in floor	2.29	Minor	15	2.03	Remote	15
Frame Work	2.38	Minor	14	2.44	Remote	10
Landscape	1.75	Negligible	17	1.6	Rare	17
Installation of lift	3.78	Moderate	2	2.84	Remote	4
Masonry	2.76	Minor	9	2.64	Remote	6
Mechanical Works	3.05	Moderate	5	2.40	Remote	12
Painting	2.38	Minor	13	2.00	Remote	16
Plastering / Rendering	2.43	Minor	12	2.24	Remote	13
Reinforced concrete Work	2.89	Minor	7	2.79	Remote	5
Roof Work	3.41	Moderate	4	3.23	Occasional	1
Structural Steel	3.63	Moderate	3	2.95	Remote	3

Table 7 summaries the safety risk assessment of the common work activities for building construction projects. Result revealed that installation of electrical work had the highest medium risk level with an average risk score of 11.48. Roof work was second with an average risk score of 11.01. Installation of lift was third in position with an average risk score of 10.74. Landscaping had the least with an average risk score of 2.80. The result shows that 16 out of the 17 making 94.12% of the work items in building construction projects are medium risk with a tolerable acceptable level risk.

Table 7: Risk Assessment of work items in building construction projects

SN	Risk Analysis of Work Items in Building Construction Projects.	Severity	Likelihood	Risk Score	Risk Level	Rank
1	Installation of electrical works	3.79	3.03	11.48	Medium	1
2	Roof work	3.41	3.23	11.01	Medium	2
3	Installation of lift	3.78	2.84	10.74	Medium	3
4	Structural steel	3.63	2.95	10.71	Medium	4
5	Reinforced Concrete work	2.89	2.79	8.06	Medium	5
6	Cladding work	2.95	2.54	7.49	Medium	6
7	Mechanical works	3.05	2.4	7.32	Medium	7
8	Excavation	2.88	2.53	7.29	Medium	8
9	Masonry	2.76	2.64	7.29	Medium	9
10	External works	2.56	2.5	6.40	Medium	10
11	Finishing in ceiling	2.53	2.42	6.12	Medium	11
12	Frame work	2.38	2.44	5.81	Medium	12
13	Plastering / Rendering	2.43	2.24	5.44	Medium	13
14	Doors and windows	2.22	2.19	4.86	Medium	14
15	Painting	2.38	2	4.76	Medium	15
16	Finishing in floor	2.29	2.03	4.65	Medium	16
17	Landscape	1.75	1.6	2.80	low	17

Discussion of Findings

Result revealed that out of the seventeen common work items, installation of lift was the most hazardous of all the work activities in building construction projects with MS=4.03 Ghousi *et al.* (2018) identified lift installation as a work item that presents approximate 10- 22% of the total risk in a project. Second was electrical works with MS=3.93, Baraban and Usmen (2006); Gurcanli *et al.* (2015); Ghousi *et al.* (2018) attested that electrical works is one of the high-risk trades in building construction projects. Third was roof work with MS=4.21, this is in line with Choi (2015) and Okoye (2018) who acknowledged that roof work had the highest safety risk in comparison with other work activities. Construction of steel structure was fourth with MS=4.24. This is in line with Ghousi *et al.* (2018) who revealed that steel structure installation is the most critical hazard in building construction projects, this could be owing to the fact that the trade is a specialist job, workers are not knowledgeable enough.

Findings from safety risk assessment revealed that the work item with the greatest risk level is electrical works with an average risk score of 11.48, Williams *et al*. (2017) identified electrocution as high-risk hazard in construction. Roof work was identified second, with an average risk score of 11.01, this is in line with Baraban and Usmen (2006) and Okoye (2018) who acknowledged roof work as a trade with frequent risk occurrence in construction. Installation of lift was third and fourth was structural steel with an average risk score of 10.74 and 10.71 respectively.

CONCLUSION AND RECOMMENDATIONS

The study determined the most hazardous work item in building construction projects. Findings revealed that the work items with high risk are, lift installation electrical works, roof work and steel structure. A risk assessment was conducted to examine the safety risk level of the various work activities. Findings revealed that the work items with the highest medium risk are, electrical works, roof work, lift installation and structural steel. The result of the study demonstrates that the differences in the type of activities and the approach of operations have different levels of risk associated with them, signifying that there are building work activities associated with high risks, medium risk and low risks. It can be concluded from the study that the majority of building construction operations sampled in Abuja are deemed to be of medium risk; nonetheless, employees are still at danger of injury and accidents on work sites that are tolerable.

It is recommended that appropriate risk identification and prioritization is a requirement for effective risk management and control, and it is suggested that all construction safety plans include an adequate risk assessment strategy. Resulting in a periodic hazard investigation being carried out leading to adequate health and safety measures been made available to control and reduce the risk, to an acceptable level on site. A further study should be carried out to assess the safety risk hazard for each work item in building construction projects. This will help stakeholders handling building projects to identify which work item have high or low risk. This will provide a starting point for scheduling workers health and safety programmes in mitigating the risks associated with construction projects. It is anticipated that stakeholder's awareness of safety hazards and associated risks during construction will be improved.

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