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RESEARCH ARTICLE

Occupational Health and Safety Risk Levels of Building Construction Trades in Nigeria

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Abstract

This study assessed the occupational health and safety risk-level of common building construction trades in Nigeria. It also identified the sources, frequency and magnitude of risks inherent in the activities of various building construction trades. Being site-based survey research, it made use of a structured questionnaire administered to the selected building construction workers of different trades in Anambra State, Nigeria. The collected data were subjected to quantitative risk analysis using mean value method and risk prioritisation number. The study found that masonry, carpentry (including formwork and roofing), and iron bending and steel fixing are common building trades associated with high risks; whereas electrical fitting and installation, painting, tiling, and plumbing are medium risk building trades. It also found that the rate of occurrence and magnitude of impact of different safety risk factors differ across the building trades, which could be attributed to the differences in activities and modes of operation in different building trades. On this premise, the study suggested a multi-risk management and control approach for construction managers on building construction sites since the frequency of risk occurrence and the magnitude of risk severity differ across trades. It further called for institutional and legislative re-strengthening of extant labour laws in Nigeria.

Keywords

Building trades, construction activities, health and safety, occupation, risk factors.

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Introduction

Building construction activities are generally associated with high risks and hazards. Building construction workers are also generally exposed to an excessive risk of being injured at work (Almen Larsson and Thunqvist, 2012). Alizadeh, Mortazavi and Sepehri (2015) acknowledged that in construction, workers perform a great diversity of activities, each one with a specific associated risk. Zavadskas, Turskis and Tamošaitiene (2010), Kozlovská and Struková (2012) and Muiruri and Mulinge (2014) also agreed that many construction activities inherently possess high health and safety risk factors. According to de los Pinos, et al. (2017), the high accident rate in the construction sector is due to a series of factors that do not occur in other sectors. However, the most recognised health and safety hazards on construction sites have been working at height, working underground, working in confined spaces and proximity to falling materials, handling load manually, handling hazardous substances, noises, dusts, using plant and equipment, fire, exposure to live cables, poor housekeeping and ergonomics (Kozlovská and Struková, 2012; Muiruri and Mulinge, 2014; Vitharana, De Silva and De Silva, 2015).

But while Hola (2010) and Kozlovská and Struková (2012) acknowledge that construction sites undergo changes in work process, topography, topology and working conditions (including weather conditions) throughout the project duration, Mhetre, Konnur and Landage (2016) observed that the construction industry is highly risk prone, with complex and dynamic project environments which create an atmosphere of high uncertainty and risk. To this end, Mhetre, Konnur and Landage (2016) maintained that the construction industry is vulnerable to various technical, socio-political and business risks; as well as physical, chemical, mechanical and social hazards (Mohamed, 2017). Specifically, Tadesse and Israel (2016) found that the prevalence of injury among building construction workers was relatively higher when compared to other sectors.

Consequently, the high injury prevalence on construction sites has been known to have huge cost implications for construction business generally. Tadesse and Israel (2016) even argued that if urgent interventions are not in place, the absence from work, loss of productivity and work-related illnesses, disabilities and fatalities will continue to be a major challenge for the construction industry in the future. Hence the importance of managing risks in construction projects to achieve the project objectives in terms of time, cost, quality, safety and environmental sustainability (Zou, Zhang and Wang, 2014). Most importantly, Occupational Safety and Health (OSH) does not only seek to secure the safety and health of persons at work but consequentially stimulates productivity in the business of the enterprise (ILO, 2016).

However, safety risk in construction cannot be effectively managed without first identifying the risk factors associated with different trades in construction. Different studies (Alinaitwe, Mwakali, and Hansson, 2007; Dėjus, 2007; Gürcanli and Müngen, 2013; Chong and Low, 2014; Asanka and Ranasinghe, 2015; Kanchana, Sivaprakash and Joseph, 2015) have also revealed that accidents occur on construction sites daily, and efforts towards minimising these have yielded few results. This may not be unconnected with diverse groups/trades of building construction workers involved on construction sites at the same and different times throughout the process of construction as stated by Muiruri and Mulinge (2014). These workers are specialists in their different building trades but are constantly exposed to high risk activities while carrying out their duties. Even Fung, et al. (2010) have attributed the high incidence of accidents on construction sites to the risky nature of construction work, low knowledge and a lack of trade risk awareness of tradesmen, among others. In most cases the works of these tradesmen run concurrently on the site, which at the same time increases the risk of injury or fatality on the site.

Because of the above scenarios, this study is aimed at assessing the occupational health and safety risk level of common building trades in Nigeria. Such assessment was evaluated through determining the source, frequency and magnitude of risk inherent in the activities of various trades in building construction. This was with a view to identifying workers who are at risk of accidents with severe consequences and classifying and prioritising the workers to determine and apply the appropriate control measures.

Literature Review

Although Lopez-valcarcel (2001) has argued that the construction industry generally is responsible for more than half of all occupational injuries and deaths worldwide, some studies associated certain building trades with high injury or fatality risks while some others are associated with low risks. For instance, Baradan and Usmen (2006) found that ironworkers and roofers were the highest risk building trades. Schneider and Susi (1994) found that masonry had the second highest incidence rate of all construction trades for injuries with lost workdays due to overexertion involving lifting. Alinaitwe, Mwakali and Hansson (2007) analysed the accidents on building construction sites reported in Uganda during 2001 – 2005 and found that labourers are the most vulnerable workers followed by masons, carpenters and plant operators.

The report of the Bureau of Labour Statistics (BLS) (2009) affirmed that masonry construction is one of the high-risk specialty trades with the nonfatal incident rate of 191.5 per 10,000 equivalent full-time workers and 2,640 recordable injuries. This report agrees with Schneider and Susi (1994). It is also supported by Memarian and Mitropoulos (2012; 2013) who identified and categorised the high-risk activities and groups in masonry construction. In addition, Choi (2015) studied the trends of injury type relating to the age and trade of construction workers in the Midwestern United States. Choi identified that the four trade/occupation groups with the highest injury rates were labourers, carpenters, iron workers, and operators.

Furthermore, a status survey of occupational risk factors of manual material handling tasks carried out in Indian construction site by Ray, Parida and Saha (2015) revealed that the risk of musculoskeletal injuries/disorders appeared to be highest among mason helpers as compared to other occupations because they suffer from pain in almost all the joints and the risk factors are also critical and versatile in nature. It also found that masons are rated as the second highest occupation facing several problems due to the peripatetic nature of construction-related manual material handling activities and highly correlated to the causes of musculoskeletal disorders; and that apart from masons and mason helpers, ground-level workers also suffer from pain causing several musculoskeletal disorders among them because they are also highly involved in manual material handling activities.

From the above studies it can be argued that the safety risk associated with any trade depends on the context, setting, and activities involved. This argument is consistent with the position of Rozenfeld, et al. (2010) who argued that the safety risk level associated with any task depends on its context; and that the circumstances of construction working environment required a detailed analysis of the various risks to which construction workers are exposed. The following literature (Einarsson, 1998; Hola, 2010; Khosravi, et al., 2014; Parida, and Ray, 2015; Hoła, and Szóstak, 2017; Mohamed, 2017) also supported the view that safety risks associated with construction workers are dependent on the context, setting and the type of activities.

However, Nigeria has no official data on accident records of construction activities. Likewise, available literature (Hofstede, 2001; Hofstede, Hofstede and Minkov, 2010; Belhoste and Monin, 2013; Oishi, 2015) has also shown that differences abound across settings, cultures, and geographies. According to Loosemore, et al. (2006), the perception of risk varies at both individual and organisational levels because different people hold different views and have different understandings of a specific risk's components, sources, probabilities, consequences and preferred actions. More specifically, the building industry is characterised by high variety and variability of working processes and work environment conditions, which is conducive to accidents at work (Hola, 2010). Therefore, risk factors, perceptions and orientations may differ in different work environment, location and culture (Cezar-Vaz, et al., 2012; Nielsen, Bergheim and Eid, 2013; Park and Kim, 2014).

In addition, there has not been any workable accident prevention intervention programme for Nigerian construction sites. The fact that the process for occupational hazard identification, risk assessment and control, risk management, and risk management techniques on construction sites and other workplaces have been dealt with in some previous studies (see Odeyinka, Oladapo and Dada, 2004; Ijigah, et al., 2013; Odimabo and Oduoza, 2013; Oranusi, Dahunsi and Idowu, 2014; Edmund, 2015; Oladokun, Adelekun and Ashimolowo, 2016; Tipili and Yakubu, 2016) did not change the safety and risk concern on the construction site. Although Okoye's proposed safety performance improvement framework (Okoye, 2016), and Okoye, Okolie and Ngwu's (2017) proposed safety intervention implementation strategy for the Nigerian construction industry may be a stepping stone towards achieving this, the tidal rise in the number of accidents on building construction sites, based on anecdotal evidence, is becoming unacceptable and totally worrisome. The weakness of legislative framework in that regard in Nigeria is most unfortunate. Thus, this is an indication of misplacement of priority in safety intervention in the construction industry.

Furthermore, while some other studies laid emphasis on the general safety management practice, accident prevention, risk management and control techniques, and safety performance, little or no studies have been done on the occupational health and safety risk level of building construction trades in Nigeria. Risk assessment therefore enables the identification of risk factors, their assessment and prioritisation (Conte, et al., 2011). The extent of damage occurring to the worker based on risk exposure is also revealed, and from which mechanisms to control risks are established (de los Pinos, et al., 2017). Unequivocally, Gadd, Keeley and Balmforth (2004) contended that the purpose of risk assessment is to determine if the levels of risk from work activities are acceptable or otherwise, and that measures must be taken to control and reduce the risk.

Nevertheless, health and safety risk assessment on construction sites, is an important measure towards reduction of hazards and injuries (Kozlovská and Struková, 2012). Since managing health and safety is different from managing any other aspect in construction there is need for a trade-based risk assessment to determine the health and safety risks inherent in building construction trades in Nigeria based on their susceptibility to construction safety risk factors, and to put sensible measures in place to control them, and make sure they stay controlled. According to Choi (2015) understanding these trade-related tasks can help present a more accurate depiction of the incident and identify trends and intervention methods to meet the needs of the workforce in the industry.

Research Method

The study was a site-based survey that made use of a structured questionnaire administered to selected building construction workers (skilled craftsmen/artisans) in Anambra State Nigeria. According to Sekaran (2003) the questionnaire is an efficient data collection mechanism when the researcher knows exactly what is required and how to measure the variables of interest. Seven common building construction trades (masonry (including concreting and blockworks); carpentry (including formwork and roofing), iron bending and steel fixing; electrical fitting and installation; painting and decorating; plumbing; and tilling) were considered for inclusion in the survey.

The questionnaire was designed to describe the current health and safety risk level of common building construction trades in Anambra State Nigeria. It was also designed to investigate the probability of occurrence and the impact of risk factors affecting the health and safety of building construction trades. According to Baradan and Usmen (2006), the simultaneous consideration of frequency and severity shows broader results than analysing risk based only on frequency or on severity. The questionnaire consisted of two parts. Part 1 captured the respondents' demographic data (trade, job position, nature of employment, site location, age of respondents, work experience, and safety training level). Part 2 contained 24 items measuring the probability of occurrence and impacts of the risk factors on building construction workers using a Likert scale of 1 to 5. The respondents were asked to express their opinion based on their perception on the frequency of occurrence and severity of impact of identified risk factors on the selected building trades on a 5-point scale. The frequency of occurrence included:1 = Rarely, 2 = Remote, 3 = Occasional, 4 = Frequent, 5 = Almost Certain (for the likelihood of risk occurrence); and 1 = Negligible, 2 = Minor, 3 = Moderate, 4 = Major, 5 = Catastrophic (severity of risk impact).

Since the entire population of building construction workers in the State is not known, Bujang, Sa'at and Tg Abu Bakar Sidik (2017) noted that the minimum required sample size for almost all types of multivariate analysis is determined conventionally, using a rule-of-thumb which is mostly derived from Multiple Linear Regression. But Siddiqui (2013) stated that the appropriate sample sizes depend upon the numbers of items available for factor analysis. To this end, Tabachnick and Fidell (2013) proposed using formula of "50 + 8m" where "m" is the number of factor, while Siddiqui (2013) suggested that for 10 items a sample size of 200 is required; for 25 items 250; for 90 items 400 and for 500 items a sample size of 1000 deemed necessary. In this case therefore, 7 latent variables and 24 indicators (factors) are available for analysis. Thus, the sample size for this study is approximately 240 building construction workers.

It was noted that there were more than five hundred building projects going on across the state at the time of this study. There are large, medium and small building projects at different stages of construction and with variety of construction workers. Most projects are privately owned residential building projects with the owners taking charge of the management of the construction process and involving fewer workers usually coming to work when their services are demanded. Moreover, most of these projects are not organised and do not have regular construction activities going on in the site.

Based on the above scenario certain criteria were set out for site selection in the survey. Therefore, for a site to be qualified for selection, the following criteria were considered, that included, *inter alia*:

- Sites with at least 5 workers;
- Sites where at least 2 trades of workers are working at the site at the time;
- Large building site with multiple activities;
- Geographical spread; and
- Not more than 2 same trade workers were selected from one site.

This specification is necessary to guide the survey and to minimise bias. Secondly, different trades of workers are involved at different stages of building construction projects and it is not possible to get all groups of workers on the same site at the same time.

Based on the stated criteria, a total of 30 building construction sites were qualified and selected for the survey. From each selected site, 8 respondents were selected amounting for a total of 240 respondents (workers) of different trades for the study. To ensure geographical spread across the state, 10 sites are selected from each of the three zones since the Anambra State politically is divided into 3 zones of North, South and Central senatorial zones.

Meanwhile, the survey involved a multi-stage sampling procedure in selecting the desired samples (respondents). A judgemental sampling technique was used in selecting the building construction sites based on the specified criteria. Secondly, a simple random sampling technique was used in choosing the worker based on their trades.

Before the distribution of the questionnaires, the participating sites were first identified, and consent/permission was sought and obtained from the site management whose sites were to be selected. The objectives of the study were clearly explained to the participants. While some sites refused to grant permission for the survey, those that granted approval were included for study until the required number was reached. This made it easier during the actual survey because the respondents were already aware of what was expected of them, and with the help of the site supervisors of selected construction sites the desired numbers of respondents were obtained. Thus, questionnaires were administered to 240 building construction workers in the selected sites across the state. Out of this, all were retrieved, but 4 were found to be invalid and subsequently discarded while the remaining 236 representing about 98.33% were found to be adequate and suitable, and thus used for analysis.

To ensure reliability of the result, the margin of error was computed at 95% confidence interval (C.I) within which the result would be acceptable. Margin of error (ME) is given as:

ME = critical value x standard error (1)

Standard error = standard deviation/$\sqrt{n}$ (2)

Where, n = the sample; The Alpha level (α): $\alpha = 1\text{-C.I}/100 = 0.05$

The critical probability (p^*): $p^* = 1 - \alpha/2 = 1 - 0.05/2 = 0.975$

The degrees of freedom (df): df = n - 1 = 240 -1 =239

Since the population standard deviation of the construction workers is not known, the critical value has been expressed as a t-statistic. In this case, it would be the t-statistic having 239 degrees of freedom and a cumulative probability equal to 0.975. From the t-Distribution, the critical value is found to be 1.96.

Thus, the result of this study is reliable within +/- 6.3% at the 95% confidence level. This is in line with Data Star (2008) which suggested that an acceptable margin of error used by survey researchers falls between 4% and 8% at the 95% confidence level.

Table 1 Risk factor probability of occurrence and risk factor impact scale

Risk Factor Probability of Occurrence			Risk Factor Impact Scale		
Scale	Rating	Description	Scale	Impact Rating	Description
1	Rarely	Not expected to occur but still possible.	1	Negligible	Not likely to cause injury or ill-health
2	Remote	Not likely to occur under normal circumstances.	2	Minor	Injury or ill-health requiring first-aid only
3	Occasional	Possible or known to occur.	3	Moderate	Injury requiring medical treatment or ill-health leading to disability.
4	Frequent	Common occurrence.	4	Major	Serious injuries or life-threatening occupational disease.
5	Almost Certain	Continual or repeating experience.	5	Catastrophic	Fatality, fatal diseases or multiple major injuries.

Workplace Safety and Health Council (2011)

The data generated through the questionnaire were then subjected to descriptive and quantitative analysis. A quantitative risk analysis was carried out to assess the risk factors. Table 1 summarised the risk factor probability of occurrence and the impact rating respectively based on the recommendation of Code of Practice on Workplace Safety and Health (WSH) Risk Management (Workplace Safety and Health Council, 2011).

However, the probability of risk occurrence is calculated using the Mean Value Method as shown below.

$$PRO = \frac{\sum_{j=1}^{5} j \times N_j}{\sum_{j=1}^{5} N_j} \tag{3}$$

Where PRO = probability of risk occurrence; j = probability of occurrence rating scale (integer values between 1and 5), and Nj = number of the respondents selecting the probability of occurrence equal to j.

Likewise, the severity of risk impact is calculated using the Mean Value Method as shown below.

$$SRI = \frac{\sum_{k=1}^{5} k \times N_k}{\sum_{k=1}^{5} N_k} \tag{4}$$

Where SRI = severity of risk impact; k= impact rating scale (integer value between 1 and 5), and Nk = number of the respondents selecting an impact equal to k.

On the other hand, the degree of risk or rather the risk score (R) is obtained through risk prioritisation number which invariably determines the level of risk. Based on the average risk values, the trades are ranked accordingly. This is computed using the following equation:

$$R = \frac{\sum PRO}{N} \times \frac{\sum SRI}{N} \tag{5}$$

Where PRO = Probability of risk occurrence, SRI = Severity of risk impact and N = Number of item.

Table 2 summarised the risk rating (degree of risk and associated description of risk level) based on the risk scale recommended by the Code of Practice on Workplace Safety and Health (WSH) Risk Management (Workplace Safety and Health Council, 2011).

Table 2 Risk rating

Risk score scale	Risk level
$1 \le x \le 4$	Low
$4 < x \le 12$	Medium
$12 < x \le 25$	High

Workplace Safety and Health Council (2011).

x = actual risk score for the considering variable (trade).

Results

Table 3 summarised the result of risk analysis on common building trades in Nigeria. The result revealed that among the seven common building trades, carpentry (including formwork and roofing) has the greatest risk level with an average risk score (R) of 13.7; while plumbing has the least risk level with an average risk score (R) of 6.0. However, in terms of frequency of risks occurrence, Table 3 revealed that carpentry (including formwork and roofing), is more susceptible to frequent risks occurrence with a PRO of 3.8 than any other trades. It is followed by masonry (block laying, brick laying, concreting and plastering) and Iron bending and steel fixing with a PRO of 3.5 each. In terms of risk impact and severity masonry (block laying, brick laying, concreting and plastering) received the greatest impact from the risk factors with SRI of 3.7. This is closely followed by carpentry (including formwork and roofing) with SRI of 3.6.

On the other hand, plumbing has both the least frequency of risk occurrence with a PRO of 2.6, and least severity of risk impact with a SRI of 2.3. Overall, the result showed that

Table 3 Summary of the result of risk analysis on common building trades

Building Trade	PRO	SRI	R	Risk Level	Rank
Carpentry (including formwork and roofing)	3.8	3.6	13.7	High	1
Masonry (block laying, brick laying, concreting and plastering)	3.5	3.7	13.0	High	2
Iron bending and steel fixing	3.5	3.5	12.3	High	3
Tilling (including terrazzo and marble laying)	3.4	3.3	11.2	Medium	4
Painting	3.1	2.9	9.0	Medium	5
Electrical fitting and Installation	2.7	2.5	6.8	Medium	6
Plumbing	2.6	2.3	6.0	Medium	7

carpentry (including formwork and roofing), masonry (block laying, brick laying, concreting and plastering) and iron bending and steel fixing are high risk level building trades, whereas, tilling (including terrazzo and marble laying), painting, electrical fitting and installation and plumbing are medium risk level building trades. This is equally related to the frequency of risk occurrence and severity of risk impact observed on the individual trade.

Table 4 Analysis of risk level of health and safety risk factors in building trades

Health and Safety Risk factors	Building Trades R							AV. R	Risk Level	Rank
	CP	MS	IB	TL	PT	EF	PB			
Falls from height	23.5	20.2	14.4	11.3	19.3	17.2	12.6	16.9	High	1
Manual handling activities	16.9	22.1	22.6	21.6	15.0	8.7	9.2	16.6	High	2
Climbing steps and working platforms	20.2	19.4	14.4	10.2	12.2	16.8	7.3	14.4	High	3
Using various types of machinery and tools	20.6	16.3	22.6	12.5	10.2	5.6	11.8	14.2	High	4
Risk of pain or injury from performing repetitive tasks	14.8	17.1	21.6	12.5	14.0	7.5	2.9	12.9	High	5
Cuts and abrasions	17.2	14.0	20.7	18.4	3.7	6.9	7.0	12.6	High	6
Risk of eye injury from flying particles and dust	14.0	14.8	9.61	14.1	12.6	10.8	10.8	12.4	High	7
Injuring whilst lifting or carrying	18.3	16.7	9.8	13.3	6.2	6.7	2.6	11.9	Medium	8
Slips trips and falls due to untidy work area	16.4	13.7	15.8	18.0	9.9	6.2	2.6	11.8	Medium	9
Risk from exposure to asbestos and hazardous substances	14.4	19.7	3.6	14.4	16.4	4.0	10.2	11.8	Medium	9

Table 4 continued

Health and Safety Risk factors	Building Trades R							AV. R	Risk Level	Rank
	CP	MS	IB	TL	PT	EF	PB			
Hand and foot injury	12.6	17.6	7.3	12.3	8.1	9.6	6.7	10.6	Medium	11
Proximity to flammable or combustible materials	11.2	6.2	3.0	4.1	18.8	14.0	14.9	10.3	Medium	12
Struck by falling objects or materials	20.2	12.6	18.9	5.0	7.5	4.2	2.7	10.2	Medium	13
Loss of fingers/limbs	11.9	12.6	20.2	12.2	4.9	6.4	3.1	10.2	Medium	13
Dermatitis	13.7	16.3	6.8	13.7	12.6	2.8	3.2	9.9	Medium	15
Risk of eye injury from solvent splashes or vapours	8.9	14.6	3.6	12.1	15.6	2.9	10.9	9.8	Medium	16
Sun exposure	17.5	15.2	14.6	3.3	10.9	2.5	2.4	9.5	Medium	17
Vibration with finger	13.0	10.9	14.7	17.6	2.7	3.2	3.5	9.4	Medium	18
Exposure to electricity. Overhead and underground cables	12.2	2.4	6.7	4.1	7.6	22.5	6.1	8.8	Medium	19
Burial by earth collapse during excavations	4.6	14.4	17.3	2.0	2.9	3.0	11.2	7.9	Medium	20
Risk of vehicle overturning	7.3	9.0	8.3	11.5	4.6	4.5	2.3	6.8	Medium	21
Struck by machinery	6.9	6.3	13.3	9.8	2.9	3.0	2.9	6.4	Medium	22
Exposure to noise	7.6	5.2	10.5	12.9	2.0	2.3	2.3	6.1	Medium	23
Moulds, fungi and bacteria	9.0	5.3	3.2	8.3	6.4	2.6	7.0	6.0	Medium	24

CP = Carpentry; MS = Masonry; IB = Iron Bending; TL = Tilling; PT = Painting; EF = Electrical Fitting; PB = Plumbing; AV. R = Average Risk Score

Table 4 showed the average risk score for risk factors generated from each building trade. Table 4 revealed that the three highest ranking risk factors within the building trades are falls from height, manual handling activities and climbing steps and working platforms with average risk scores (R) of 16.9, 16.6 and 14.4 respectively. It also showed that struck by machinery, exposure to noise, and moulds, fungi and bacteria the three lowest ranking risk factors for the building trades with average risk scores of 6.4, 6.1 and 6.0 respectively. Invariably, this rank represents the level of contribution of each of the factors to health and safety risks in building trades.

On the trade-by-trade basis, Table 4 also revealed that all the factors are high, medium or low-level risk factor in one trade or the other but for risk of vehicle overturning and mould, fungi and bacteria which are medium and low level contributory risk factor. However, on the average; none is a low level contributory risk factor.

Table 5 revealed that the three most occurring health and safety risk factors for building trades are manual handling activities, falls from height, and using various types of machinery and tools with average PROs of 4.6, 4.0 and 3.9 respectively. Likewise, the three most severe and impactful health and safety risk factors for building trades are falls from height, climbing steps and working platforms and manual handling activities with SRIs of 4.2, 3.7 and 3.6 respectively.

Table 5 Analysis of frequency and impact of health and safety risk factors in building trades

Health and Safety Risk factors	Average PRO	Frequency of Occurrence Rating	Average SRI	Impact Rating
Falls from height	4.0	Frequent	4.2	Major
Manual handling activities	4.6	Almost certain	3.6	Major
Climbing steps and working platforms	3.8	Frequent	3.7	Major
Using various types of machinery and tools	4.0	Frequent	3.4	Moderate
Risk of pain or injury from performing repetitive tasks	3.6	Frequent	3.4	Moderate
Cuts and abrasions	3.5	Frequent	3.4	Moderate
Risk of eye injury from flying particles and dust	3.5	Frequent	3.4	Moderate
Injuring whilst lifting or carrying	3.6	Frequent	3.1	Moderate
Slips trips and falls due to untidy work area	3.3	Occasional	3.4	Moderate
Risk from exposure to asbestos and hazardous substances	3.3	Occasional	3.3	Moderate
Hand and foot injury	3.3	Occasional	3.2	Moderate
Proximity to flammable or combustible materials	3.1	Occasional	3.1	Moderate
Struck by falling objects or materials	3.1	Occasional	3.0	Moderate
Loss of fingers/limbs	2.8	Occasional	3.4	Moderate
Dermatitis	3.0	Occasional	3.0	Moderate

Table 5 continued

Health and Safety Risk factors	Average PRO	Frequency of Occurrence Rating	Average SRI	Impact Rating
Risk of eye injury from solvent splashes or vapours	3.0	Occasional	3.0	Moderate
Sun exposure	3.3	Occasional	2.6	Moderate
Vibration with finger	3.0	Occasional	2.8	Moderate
Exposure to electricity. Overhead and underground cables	3.1	Occasional	2.6	Moderate
Burial by earth collapse during excavations	2.7	Occasional	2.6	Moderate
Risk of vehicle overturning	2.1	Remote	3.0	Moderate
Struck by machinery	2.2	Remote	2.8	Moderate
Exposure to noise	2.4	Remote	2.3	Minor
Moulds, fungi and bacteria	2.4	Remote	2.3	Minor

On the other hands, the two least occurring health and safety risk factors for building trades are risk of vehicle overturning, and struck by machinery, with the PROs of 2.1 and 2.2 respectively. Likewise, the two least severe and impactful health and safety risk factors for building trades are exposure to noise, and moulds, fungi and bacteria with SRIs of 2.3 each.

Furthermore, risks almost certainly occur from manual handling activities only while risks remotely occur from the risk of vehicle overturning, struck by machinery, exposure to noise, and moulds, fungi and bacteria. Risks either occur frequently or occasionally from the rest of the factors.

In the same vein, the impact of risks arising from falls from height, climbing steps and working platforms and manual handling activities are majorly felt on the building trades while those arising from exposure to noise, and moulds, fungi and bacteria have minor impacts on the trades. Risks arising from the rest of other factors are moderately felt.

Discussions

The result of this study has demonstrated that the risks inherent in building construction trades are many and varied. It has also affirmed that different building trades have different levels of risks associated with them. This implies that depending on the nature and types of activities involved in any trade, there are different dimensions and magnitude of risks in building operations. This further implies that there are building trades associated with high risks which are unacceptable, so also those associated with low risks which can be tolerated. In this case, the study revealed that masonry (block laying, brick laying, concreting and plastering), carpentry (including formwork and roofing), and iron bending and steel fixing are common building trades associated with high risks; whereas electrical fitting and installation, painting, tiling (including terrazzo and marble laying), and plumbing are medium risk building trades. This is to say that all the common building trades in Nigeria are still prone to injury, disease and fatalities. It then implied that activities in the high-risk trades need to be carried out with caution, while measures are to be taken to control and reduce the risks to the acceptable level. This is in line with Gadd, Keeley and Balmforth (2004) who suggested that if the levels of risk from work activities are unacceptable, measures must be taken to control and reduce the risk.

Furthermore, even though the study identified the status of building trades as either high or medium risk trades, it found that the rate of occurrence and impact also differed across trades. In other words, while some trades have high frequency of risk occurrence, some experience high severity of risk impact and vice versa. In this case, carpentry (including formwork and roofing), masonry (block laying, brick laying, concreting and plastering), iron bending and steel fixing, tiling (including terrazzo and marble laying), and painting have high frequency of risk occurrence, while masonry (block laying, brick laying, concreting and plastering), carpentry (including formwork and roofing), iron bending and steel fixing, and tiling (including terrazzo and marble laying), have high severity of risk impact. This then suggested that different approaches should be applied in the management of health and safety risks in construction across building trades.

Significantly, none of the trades was found at the upper end of high risk level. This may be suggestive of some improvements in the risk management processes of the construction industry in Nigeria. But at the same time, none of the trades was found to be at low level risk which also implied the need for further improvement to reduce the risk level of building trades and associated accident rates on site. Overall, the result implied that the occupational risk factors are strongly associated with construction occupations.

Similarly, the rate of occurrence and magnitude of impact of different safety risk factors also differed across building trades. This meant that while some risk factors occur more frequently in certain trades, they occur less frequently in some others. On the other hand; while the impacts of some risk factors are felt more severely in certain trades, they exert less impact on some others. This could be attributed to the differences in the types of activities and mode of operations involved in different building trades. It also gave credence that health and safety risk management in construction industry is multifaceted, and thus required multiple management approaches. Meanwhile, this is in tandem with the provisions of Health and Safety: Risk Assessment Methodology (University of Melbourne, 2017) which stated that risks are controlled using a combination of control measures and must be implemented in accordance with the risk control priorities established during the risk assessment.

The overall result of this study supports the results of the Bureau of Labour Statistics (2009), Schneider and Susi (1994), Baradan and Usmen (2006), López-Arquillos et al. (2014) and Choi (2015) which recognised carpentry (including, formwork and roofing), masonry (block laying, brick laying, concreting and plastering), iron bending and steel fixing as high-risk building construction trades. The result of the study is also consistent with the results of Kozlovská and Struková (2012), Muiruri and Mulinge (2014), and Vitharana, De Silva and De Silva (2015) that identified working at height, handling load manually, handling hazardous substances, dusts, using plant and equipment, fire, exposure to live cables, poor housekeeping and ergonomics as some of the most recognised health and safety hazards on building construction sites.

Conclusion

Proper and adequate risk identification and prioritisation have been determined as prerequisites for effective risk control and management. The fact is that building construction activities and trades are embodiments of health and safety risks and hazards, and that accident happens more frequently at construction sites because of the activities of construction workers. This demands a further insight into the health and safety risk level inherent in various building construction trades in Nigeria. Thus, this study has examined the occupational health and safety risk level of the activities of common building trades in Nigeria.

Indubitably, this study provides some positive practical implications. Specifically, it contributes to both practice and research in risk management for the Nigerian construction industry and provides valuable information for site-based construction management practice in Nigeria. It also provides the basis for developing appropriate guidelines for construction workers to ensure a sustainable change in the construction work systems with reduction in occupational hazards to a large extent, and to improve health, safety and performance of workers under the prevailing construction work environment in Nigeria. It calls for a need to develop appropriate strategies for curbing or mitigating the risks associated with building construction practice, especially those with high risk levels. In addition, it has succeeded in prioritising the risk levels and risk factors of building trades in Nigeria; thereby providing a useful asset to construction managers and safety professionals. .

Moreover, the research findings provide construction practitioners with further evidence of the hazardous activities associated with different building construction trades and a starting point for targeting worker health and safety programmes. The findings provide a direction for more effective safety management strategies and occupational accident prevention and emergency programmes. Thus, it has challenged the extant labour laws in Nigeria and more importantly, the provisions of the section 17 subsection 3 of the 1999 Constitution (as amended) of the Federal Republic of Nigeria, and calls for institutional and legislative re-strengthening.

Based on this result, the study avers that a multi-risk management and accident prevention approach should be adopted by the construction managers on building construction sites since the frequency of risk occurrence and the magnitude of risk severity differs across trades. The same approaches should be adopted for all the risk factors involved in the building trades since building trades involve multiple and varied risk activities. Finally, it suggests that the risk response strategies appropriate for each type of identified risk factor in each trade should be varied.

References

Alinaitwe, H., Mwakali, J.A. and Hansson, B., 2007. Analysis of accidents on building construction sites reported in Uganda during 2001 – 2005. *Proceedings of the CIB World Building Congress 2007*, pp.1208-21.

Alizadeh, S.S., Mortazavi, S.B. and Sepehri, M.M., 2015. Assessment of accident severity in the construction industry using the Bayesian theorem. *International Journal of Occupational Safety and Ergonomics,* [e-journal] 21(4), pp.551-57. https://doi.org/10.1080/10803548.2015.1095546.

Almen, L., Larsson, T.J. and Thunqvist, E., 2012. The influence of the designer on the risk of falling from heights and of exposure to excessive workloads on two construction sites. *Safety Science Monitor,* 16(1), pp.2-7.

Asanka, W.A. and Ranasinghe, M., 2015. Study on the impact of accidents on construction projects. *6th International Conference on Structural Engineering and Construction Management,* pp.58-67, Kandy, Sri Lanka 11th – 13th December.

Baradan, S. and Usmen, M.A., 2006. Comparative injury and fatality risk analysis of building trades. *Journal of Construction Engineering and Management,*[e-journal] 132(5). https://doi.org/10.1061/(ASCE)0733-9364(2006)132:5(533).

Belhoste, N. and Monin, P., 2013. Constructing differences in a cross-cultural context: National distance, social differentiation or functional distinction. *Human Relations*, [e-journal] 66(12), pp.1-35. https://doi.org/10.1177/0018726713484943.

Bujang, M.A., Sa'at, N. and Tg Abu Bakar Sidik, T.M.I., 2017. Determination of minimum sample size requirement for multiple linear regression and analysis of covariance based on experimental and non-experimental studies. *Epidemiology Biostatistics and Public Health*, [e-journal] 14(3). https://doi.org/10.2427/12117.

Bureau of Labour Statistics, 2009. Incidence rate for nonfatal occupational injuries and illnesses. [online] Available at: https://www.bls.gov/iif/oshwc/osh/case/ostb2454.pdf. [Accessed 10 November 2017]

Cezar-Vaz, M.R., Rocha, L.P., Clari Bonow, C.A., da Silva, M.R.S., Vaz, J.C. and Cardoso, L.S., 2012. Risk perception and occupational accidents: a study of gas station workers in Southern Brazil. *International Journal of Environmental Research and Public Health*, [e-journal] 9, pp.2362-77. https://doi.org/10.3390/ijerph9072362.

Choi, S.D., 2015. Aging workers and trade-related injuries in the US construction industry. *Safety and Health at Work*, [e-journal] 6, pp.151-55. https://dx.doi.org/10.1016/j.shaw.2015.02.002.

Chong, H.Y. and Low, T.S., 2014. Accidents in Malaysian construction industry: statistical data and court cases. *International Journal of Occupational Safety and Ergonomics,* [e-journal] 20(3), pp.503-13. https://doi.org/10.1080/10803548.2014.11077064.

Conte, J.C., Rubio, E., García, A.I. and Cano, F., 2011. Occupational accidents model based on risk–injury affinity groups. *Safety Science,*[e-journal]49(2), pp.306-14. https://doi.org/10.1016/j.ssci.2010.09.005.

Data Star, 2008. What every researcher should know about statistical significance. [online] Available at: https://www.surveystar.com/startips. [Accessed 10 November 2017].

de los Pinos, C., José, A., García, G. and de las Nieves, M., 2017. Critical analysis of risk assessment methods applied to construction works. Revista de la Construcción, [e-journal] 16(1), pp.104-14. https://doi.org/10.7764/RDLC.16.1.104.

Dėjus, T., 2007. Accidents on construction sites and their reasons. *The 8th International Conference on Modern Building Materials, Structures and Techniques,* Vilnius, Lithuania May 16-18, 2007.

Edmund, E.E., 2015. Analysis of occupational hazards and safety of workers in selected working environments within Enugu Metropolis. *Journal of Environmental & Analytical Toxicology,*[e-journal] 5(6). https://dx.doi.org/10.4172/2161-0525.1000337.

Einarsson, S., 1998. The relationship between construction contractors and their clients in petrochemical and related industries. *Safety Science Monitor*, 2(2), pp.1-19.

Fung, I.W.H., Tam, V.W.Y., Lo, T.Y. and Lu, L.L.H., 2010. Developing a risk assessment model for construction safety. *International Journal of Project Management*, 28(6), pp.593-600. https://doi.org/10.1016/j.ijproman.2009.09.006

Gadd, S.A., Keeley, D.M. and Balmforth, H.F., 2004. Pitfalls in risk assessment: examples from the UK. *Safety Science,*[e-journal] 42(9), pp.841-57. https://doi.org/10.1016/j.ssci.2004.03.003.

Gürcanli, G.E. and Müngen, U., 2013. Analysis of construction accidents in Turkey and responsible parties. *Industrial Health*, 51, pp.581-95. https://doi.org/10.2486/indhealth.2012-0139

Hofstede, G., 2001. *Culture's consequences: comparing values, behaviours, institutions and organisations across nations*. 2nd ed. Thousand Oaks, CA: Sage. https://doi.org/10.5465/amr.2002.7389951

Hofstede, G., Hofstede, G.J. and Minkov, M., 2010. *Cultures and organisations: software of the Mind*. 3rd ed. New York: McGraw-Hill. https://doi.org/10.1177/017084069401500308

Hoła, B. and Szóstak, M., 2017. Methodology of analysing the accident rate in the construction industry. *Procedia Engineering*, [e-journal] 172, pp.355-62. https://doi.org/10.1016/j.proeng.2017.02.040.

Hoła, B., 2010. Methodology of hazards identification in construction work course. *Journal of Civil Engineering and Management*,[e-journal]16(4), pp.577-85. https://doi.org/10.3846/jcem.2010.64.

Ijigah, E.A., Jimoh, R.A., Bilau, A.A and Agbo, A.E., 2013. Assessment of risk management practices in Nigerian construction industry: towards establishing risk management index. *International Journal of Pure and Applied Science and Technology,* 16(2), pp.20-31.

International Labour Organisation (ILO), 2016. Nigeria country profile on occupational safety and health. [online] Available at: https://www.ilo.org/wcmsp5/groups/public/---africa/---ro-addis_ababa/---ilo-abuja/documents/publication/wcms. [Accessed 10 November 2017].

Kanchana, S., Sivaprakash, P. and Joseph, S., 2015. Studies on labour safety in construction sites. *The Scientific World Journal*, [e-journal] 2015, 6 pages. https://doi.org/10.1155/2015/590810.

Khosravi, Y., Asilian-Mahabadi, H., Hajizadeh, E., Hassanzadeh-Rangi, N., Bastani, H. and Behzadan, A.H., 2014. Factors influencing unsafe behaviors and accidents on construction sites: A review, *International Journal of Occupational Safety and Ergonomics,* [e-journal] 20(1), pp.111-25, https://doi.org/10.1080/10803548.2014.11077023.

Kozlovská, M. and Struková, Z., 2012. Overview of safety risk perception in construction. *Journal of Civil Engineering and Architecture,* 6(2), pp. 211-18. https://doi.org/10.17265/1934-7359/2012.02.010

Loosemore, M., Raftery, J, Reilly, C. and Higgon, D., 2006. *Risk management in projects*. 2nd ed. Oxford, UK: Taylor and Francis. https://doi.org/10.1680/mpal.2007.160.4.181

López-Arquillos, A., Rubio-Romero, J.C., Gibb, A.G. and Gambatese J.A., 2014. Safety risk assessment for vertical concrete formwork activities in civil engineering construction. *Work,* [e-journal] 49(2), pp.183-92. https://doi.org/10.3233/WOR-131724.

Lopez-valcarcel A., 2001. Occupational safety and health in the construction work. *Occupational Health and Safety: African News,* 11, pp.4-7.

Memarian, B. and Mitropoulos, P., 2012. Safety incidents and high-risk activities of masonry construction.,*Proceedings of the Construction Research Congress,* 2012,pp.2510-19, West Lafayette, Indiana, USA, 21-23 May. https://doi.org/10.1061/9780784412329.252

Memarian, B. and Mitropoulos, P., 2013. Accidents in masonry construction: The contribution of production activities to accidents, and the effect on different worker groups. *Safety Science,* [e-journal] 59, pp.179-86. https://doi.org/10.1016/j.ssci.2013.05.013.

Mhetre, K. Konnur, B.A. Landage, A.B., 2016. Risk management in construction industry. *International Journal of Engineering Research,* [e-journal] 5(1), pp.153-55. https://doi.org/10.17950/ijer/v5i1/035.

Mohamed, H.A., 2017. Occupational hazards and their relation with health problems among construction building workers at El Sherouk City. *American Journal of Nursing Research*, [e-journal] 5(3), pp.96-103. https://doi.org/10.12691/ajnr-5-3-4.

Muiruri, G. and Mulinge, C., 2014. Health and safety management on construction project sites in Kenya: a case study of construction projects in Nairobi County. In: *FIG Congress,* Kuala Lumpur, Malaysia, 16-21 June 2014.

Nielsen, M.B., Bergheim, K. and Eid, J., 2013. Relationships between work environment factors and workers' well-being in the maritime industry. *International Maritime Health*, [e-journal] 64(2), pp.80-88.

Odeyinka, H.A., Oladapo, A.A. and Dada, J.O. 2004. An assessment of risk in construction in the Nigerian construction industry. In: *Proceedings of CIB, W107, international Symposium on Globalisation and Construction,* AIT Conference Centre, Bangkok, Thailand, 17-19 November 2004.

Odimabo, O.O. and Oduoza, C.F., 2013. Risk assessment framework for building construction projects' in developing countries. *International Journal of Construction Engineering and Management*, [e-journal] 2(5), pp.143-54. https://doi.org/10.5923/j.ijcem.20130205.02.

Oishi, S., 2015. Geography and personality: Why do different neighborhoods have different vibes? *Proceedings of the National Academy of Science of the United States America*. [e-journal] 112(3), pp.645-46. https://dx.doi.org/10.1073/pnas.1423744112.

Okoye, P.U., 2016. Improving the safety performance of Nigeria construction workers: a social ecological approach. *Universal Journal of Engineering Science*, [e-journal] 4(2), pp.22-37. https://doi.org/10.13189/ujes.2016.040202.

Okoye, P.U., Okolie, K.C. and Ngwu, C., 2017. Multilevel safety intervention implementation strategies for Nigeria construction industry. *Journal of Construction Engineering,* [e-journal] 2017, https://doi.org/10.1155/2017/8496258.

Oladokun, M.G., Adelekun, A.D. and Ashimolowo, D.O., 2016. Evaluation of risk management techniques in developing economies: a case of Nigeria. *PM World Journal.* 5(8).

Oranusi, U.S., Dahunsi, S.O. and Idowu, S.A., 2014.Assessment of occupational diseases among artisans and factory workers in Ifo, Nigeria. *Journal of Scientific Research & Reports,* 3(2), pp.294-305. https://doi.org/10.9734/jsrr/2014/5554

Parida, R. and Ray, P.K., 2015. Factors influencing construction ergonomic performance in India. *Procedia Manufacturing*, [e-journal] 3, pp. 6587-92 . https://doi.org/10.1016/j.promfg.2015.07.284.

Park, S. and Kim, J.G., 2014. Risk and culture: variations in dioxin risk perceptions, behavioral preferences among social groups in South Korea. *Environmental Health and Toxicology*, [e-journal]29. https://dx.doi.org/10.5620/eht.e2014013.

Ray, P.K., Parida, R. and Saha, E., 2015. Status survey of occupational risk factors of manual material handling tasks at a construction site in India. *Procedia Manufacturing,* [e-journal] 3, pp.6579-86. https://doi.org/10.1016/j.promfg.2015.07.279.

Rozenfeld, O., Sacks, R., Rosenfeld, Y. and Baum, H., 2010. Construction job safety analysis. *Safety Science*, 48, pp.491-98. https://doi.org/10.1016/j.ssci.2009.12.017

Schneider, S. and Susi, P., 1994. Ergonomics and construction: Review of potential hazards in new construction. *American Industrial Hygiene Association Journal,* 55(7), pp.635-49. https://doi.org/10.1080/15428119491018727

Sekeran, U., 2003. *Research methods for business.* 4th ed. United States of America: John Wiley & Sons Inc.

Siddiqui, K., 2013. Heuristics for sample size determination in multivariate statistical techniques. *World Applied Sciences Journal*, [e-journal] 27(2), pp. 285-87. https://doi.org/10.5829/idosi.wasj.2013.27.02.889.

Tabachnick, B.G. and Fidell, L.S., 2013. Using Multivariate Statistics. 6th ed.Boston: Pearson Education. https://doi.org/10.1007/978-3-642-04898-2_394

Tadesse, S. and Israel, D., 2016. Occupational injuries among building construction workers in Addis Ababa, Ethiopia. *Journal of Occupational Medicine and Toxicology,* [e-journal] 11(16). https://doi.org/10.1186/s12995-016-0107-8.

The Federal Republic of Nigeria, 1999. Constitution of the Federal Republic of Nigeria 1999.

The University of Melbourne, 2017. *Risk assessment methodology*. The University of Melbourne Australia. [online] Available at: https://safety.unimelb.edu.au. [Accessed 15 October 2017].

Tipili, L.G. and Yakubu, I., 2016. Identification and assessment of key risk factors affecting public construction projects in Nigeria: Stakeholders perspectives. International *Journal of Engineering and Advanced Technology Studies,* 4(2), pp.20-32.

Vitharana, V.H.P., De Silva, G.H.M.J.S. and De Silva, S., 2015. Health hazards, risk and safety practices in construction sites - a review study. *ENGINEER,* 48(3), pp.35-44. https://doi.org/10.4038/engineer.v48i3.6840

Workplace Safety and Health Council, 2011. *Code of practice on workplace safety and health (WSH) risk management*. The Workplace Safety and Health Council in collaboration with the Ministry of Manpower. [online] Available at: www.wshc.sg. [Accessed 1 July 2017].

Zavadskas, E.K., Turskis, Z. and Tamošaitiene, J., 2010. Risk assessment of construction projects. Journal of Civil Engineering and Management, [e-journal] 16(1), pp.33-46. https://dx.doi.org/10.3846/jcem.2010.03.

Zou, P.X.W., Zhang, G. and Wang, J.Y., 2014. Identifying key risks in construction projects: life cycle and stakeholder perspectives. *International Journal of Construction Management,* [e-journal] 9(1). https://doi.org/10.1080/15623599.2009.10773122.