RISK ASSESSMENT OF OCCUPATIONAL HEALTH HAZARDS AMONG CONSTRUCTION AND BUILDING WORKERS

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Abstract

Introduction: Construction and building work includes many hazardous tasks and conditions such as working with height, excavation, noise, dust, power tools, and equipment. Risk assessments help to ensure the health and safety of workers by identifying potential hazards for better working conditions and outcome. **Aim of Work:** To assess the magnitude and types of occupational health hazards among construction and building workers and to carry out risk assessment for occupational health hazards to which construction and building workers are exposed. **Materials and Methods:** Two hundred and eight workers participated in a cross sectional study conducted at El-Alamein city. A semi-structured questionnaire was used to assess sociodemographic, occupational history and occupational health hazards among workers. A classical Risk Formula was used to identify occupational health hazards perceived by workers. **Results:** Physical hazards reported by workers were noise (72.1%), broken floor and slippery floors (64.9%, 59.1%) respectively. The majority of chemical hazards were cement, sand dust (88.5%), concrete (62%), toxic gases and solvent paints (23.6%, 13%) respectively, and 40.8% exposed to biological hazards. The most common mechanical hazards group were trauma and injuries (46.6%), varicose veins (33.6%), friction and trapping (19.2), hitting by rapidly moving equipment (17.3%). The most common ergonomic hazards were inappropriate working posture (82.7%), prolonged standing and trunkal twisting (76%). Noise, slippery floors, broken falls, cement, concrete, sand dust, heavy tools and inappropriate working posture ranked the highest risk by classical risk formula. **Conclusion and Recommendations:** Construction and building workers are exposed to occupational hazards, and safety precautions are recommended.

Keywords: Risk assessment, Occupational health hazards, Construction and Building workers.

Introduction

Construction is one of the fastest expanding sectors, employing around 180 million people, or 7% of the worldwide workforce. Egypt's construction sector is one of the country's largest and fastest growing industries, employing around 70% of casual wage workers (Sehsah et al., 2020).

Risk assessment is a critical step in any construction project. A risk assessment analyzes and assesses the potential hazards and risks associated with a specific undertaking or activity. It entails determining the probability and severity perceived from harm or injury to individuals, property damage, and severe environmental consequences (Hegde and Rokseth, 2020).

The coordination of actions to guide and regulate an organization with respect to risk is known as risk management. In general, risk management refers to all of the choices that must be made in order to identify, evaluate, and quantify risks. Efficient risk management can enhance an organization's operational performance, competitive value, and reputation in addition to lowering losses, expenses, and social resource waste (Liu et al., 2023).

To continuously improve risk assessments in projects, 3x3, 4x4, and 5x5 risk matrices are the most commonly used sizes. Three likelihood levels (Improbable, Occasional and probable) and three severity levels (Marginal, Moderate, and Critical) make up a 3x3 risk matrix. You can determine the acceptable level of a risk by multiplying the probability and severity values of the hazard. The 3×3 matrix is prone to mistakes due to its simplistic design. A 4×4 or 5×5 matrix can be utilized for intricate tasks or risks. Second, there are four probability levels in the 4x4-risk matrix. Compared to the 3×3 template this is simpler. For many projects, a 4x4 matrix is "just right" since a matrix that is too big or tiny might not provide an adequate or precise assessment. Occupational professionals may conduct risk assessments with the greatest clarity and detail when they use a 5 x 5-risk matrix. Some contend that using a 5x5 matrix for smaller projects is excessively labor-intensive and complex. It becomes debatable for some tasks if this degree of granularity is actually required (Forteza et al., 2016).

Aim of Work

To assess the magnitude and types

of occupational health hazards among construction and building workers and to carry out risk assessment for occupational health hazards to which construction and building workers are exposed.

Materials and Methods

Study design: Cross-sectional study was carried out.

Place and duration of the study: This study was conducted at El-Alamein City, Matrouh Governorate from August 2022 to August 2023.

Study sample:

The study was conducted on 208 workers. Assuming that the total number of construction workers was 4000, and the estimated frequency of varicose vein was 17.2% (Mohamed, 2017). (We selected the varicose veins as the sample was calculated according to the least possible effect according to the reference). At 95% CI and effect size =1, the estimated sample was 208 workers using OPEN-EPI Program. The sampling was multi-stage (Firstly; there were ten companies and, one company was selected randomly. Number of construction workers at this company was 350, samples (208) were taken by simple random sample. Inclusion criteria was; building and construction workers above 18 years old, at least one year of work in the current job and workers were working at all processes of building were included. Exclusion criteria were; building and construction workers below 18 years old, females and less than one year of work .

Study methods

A semi-structured questionnaire was adapted from previous studies (Mohamed, 2017, Nirmala and Prasad, 2019, Ellaban et al., 2020). The questions covered the following sections:

Section I: socio-demographic data and occupational history of workers: age, Body Mass Index (BMI) (It was assessed by measuring weight and height), marital status, educational level, smoking status, drug abuse, past medical history residence, income, previous work, work another job, employment pattern, shift work, type of job, duration of employment and number of worked hours/day, type of task and personal protective equipment (PPE) used.

Section II: Occupational health hazards and difficulties as seen by the studied workers: physical, chemical, biological, mechanical and ergonomic risk.

Section III: Risk assessment of health hazards reported by workers using the classic Risk formula: Risk = P * S (P; probability, S; severity) (Antonucci et al., 2010, Chan et al., 2011, Flammini et al., 2011, Ellaban et al., 2020). The probability (x-axis) represents the degree of likelihood that the risk will materialize. The 5-risk rating are as follows:

- Rare – unlikely to occur and/or have minor or negligible outcome (score 1)
- Unlikely – possible to occur and/or to have moderate outcome (score 2).
- Moderate – likely to occur and/or to have serious outcome (score 3).
- Likely – almost sure to occur and/or to have major outcome (score 4).
- Almost certain – sure to occur and/or have major outcome (score 5).

Impact; called also, severity or consequences, the Impact (y-axis) seeks to identify the level of potential effects that the hazard can have on occupational health and safety. The following characterize the general expressions used to describe the 5 levels to determine the impact of risk:

- Insignificant –will not cause severe damages or illnesses (score 1).
- Minor – can cause mild damages or illnesses (score 2).
- Significant – can cause damages or illnesses that may need medical intervention but limited treatment (score 3).
- Major – can cause irreversible damages or illnesses that need continuous medical intervention (score 4).
- Severe – can cause mortality (score 5). Then, **the risk perception** was categorized as: (1 - 4) Acceptable/ NO risk, (5 - 9) Low risk, (10 - 15) Medium risk, (16 -25) High risk.

Validation

A pilot study was conducted one month prior to the start of the current study in order to identify potential issues with data collection, evaluate the validity and reliability of the questionnaire following translation, and ascertain the duration required for data collection. The questionnaire was translated into Arabic by linguistic specialists, and then back into English. The questions› Cronbach›s alpha was 0.753. These findings demonstrated the intrinsic consistency and dependability

of every item. It took the participants close to twenty minutes to complete the questionnaire. The pilot data were not included in the final analysis.

Consent

Informed consent was taken from all the studied participants after telling them the aim of the study and that the information would be for scientific purposes.

Ethical Approval

The Institutional Review Board (IRB) of Zagazig University's Faculty of Medicine approved the study protocol (#9628/2-7-2022). The study followed the Helsinki Declaration and its subsequent amendments' ethical principles.

Data Management

Utilizing Microsoft Excel software, data gathered from the questionnaire is coded, inputted, and examined for outcome measures. The Statistical Package for the Social Sciences (SPSS version 26.0) software was used to import the data and analyze them (IBM, 2020). Depending on the type of data, Mean ± SD was used to represent quantitative data while numbers and percentages were used to represent qualitative data. The coding system was; Yes and NO questions where NO=(0), Yes =(1). Other questions were coded from 0 to 1,2,3 …… from least to most.

Results

Table 1: Sociodemographic data of the studied participants

Sociodemographic data		**(No = 208)**	
Age (years)	Mean±SD	36.59 ± 12.07	
BMI	Mean±SD	27.31 ± 5.16	
		No	%
Education	Illiterate	58	27.9
	Write and read	44	21.2
	Primary	22	10.6
	Secondary	60	28.8
	University	24	11.7
Marital status	Married	149	71.6
	Unmarried	59	28.4
Tobacco smoking	non-smoker	60	28.8
	Ex-smoker	35	16.8
	Current smoker	113	54.3
Drug abuse	Yes	10	4.8
Past medical history	Diabetes	12	5.8
	Atopic history	36	17.3
	Hypertension	12	5.76
Residence	Urban	82	39.4
	Rural	126	60.6
Monthly income	Not enough	101	48.6
	Enough	97	46.6
	More than enough	10	4.8

BMI: Body mass index

Table 1 showed that the mean age of workers was 36.59±12.07, and the mean of BMI was 27.31±5.16. More than half of workers were married, lived in rural and current smokers.

Table 2: Occupational history of the studied participants.

Occupational history		(No = 208)	
		No	%
Working previous job	NO	208	100.0
	Yes	0	0.00
Work another job	NO	208	100.0
	Yes	0	0.00
Employment pattern	Permanent	21	10.1
	Temporary	187	89.9
Shift work	Day	186	89.4
	Night	22	10.6
Type of Job	Concrete formation	63	30.28
	Building	38	18.26
	Black smith workers	15	7.21
	Scaffolding	14	6.73
	Construction	12	5.76
	Plastering	12	5.76
	Driving	11	5.28
	Painting	11	5.28
	Carpentering	8	3.84
	Electricians	6	2.88
	Laborers	5	2.40
	Plumbing	5	2.40
	Ceramic worker	4	1.92
	Digging	4	1.92
Duration of working (years)	Mean ±SD	16.17 ± 4.31	
Number of working hours/day	Mean ±SD	9.19 ± 2.57	

Table 2 showed that the studied participants had neither previous jobs nor another one. Their daily shift was 89.4% with mean duration of work was 16.17±4.31 years and the mean number of working hours/day was 9.19±2.57. The most common tasks of the studied workers were concrete formation (30.28%), building (18.26%), blacksmithing and installation of scaffolding worker (7.21%) and (6.73%) respectively. The most common used PPE was steel toe and steel hats (95.7%) followed by boats and gloves (92.3% - 74%) respectively (results were not tabulated).

Table 3: Occupational hazards and problems among the studied participants.

Occupational hazards	(No = 208)	
	No	%
***Physical hazards**		
Noise	150	72.1
Poor illumination	81	38.9
Electricity	55	26.4
Fire	15	7.2
Slippery floors	123	59.1
Broken stairs	135	64.9
Vibration	53	25.5
***Chemical hazards**		
Cement, sand dust	184	88.5
Concrete	129	62
Toxic gases and chemicals#	49	23.6
Solvents paints	27	13
***Biological hazards ##**		
NO	123	59.1
Yes	85	40.9
Mechanical*		
Trauma and injuries	97	46.6
Friction and trapping	40	19.2
Hit by rapidly moving equipment	36	17.3
Varicose veins	70	33.6
Ergonomic risk*		
Prolonged standing and trunk twisting	158	76
Inappropriate working posture	172	82.7

#:Toxic gases and chemicals: as Volatile Organic Compounds (VOCs), lead, asbestos, silica.
##:Biological hazards: as stray animal bite, snake, scorpion and mosquito bite and rodent exposure.

Table 3 showed that physical hazards which were reported by the studied workers were noise (72.1%), broken floor and slippery floors (64.9%, 59.1%) respectively. The majority of chemical hazards reported were cement, sand dust (88.5%), concrete (62%), toxic gases and solvent paints (23.6%, 13%) respectively, and also showed that 4.8% were exposed to biological hazard. The most common mechanical hazards reported were trauma and injuries (46.6%), varicose veins (33.6%), friction and trapping (19.2), hitting by rapidly moving equipment (17.3%). The most common ergonomic risk reported was inappropriate working posture (82.7%), prolonged standing and truncal twisting (76%).

Steps for risk assessment;

a) For each identified hazard; risk matrix was conducted one by one. The risk matrix for our studied population was reported in Table (4).

b) After application of all hazards by risk matrix, the most common, predominant hazards were tabulated with risk index (15-25) which is danger stages, solutions must be found immediately as in Table (5). The highest matrix index in the present study were noise, slippery floor, broken floor, cement, concrete, sand dust, heavy tools and inappropriate working posture.

a) **Table 4: Identified hazards with their risk indices.**

Hazards	Probability (P)	Severity (S)	Risk Index (PxS)
Noise	5	4	20
Slippery floors	5	4	20
Broken floors	5	4	20
Cement, concrete, sand dust	5	4	20
Heavy tools	5	4	20
Slippery floors	5	4	20
Broken floors	5	4	20
Inappropriate working posture	5	4	20
Prolonged walking, standing	4	4	16
Hit by rapidly moving equipment	3	5	15
Varicose veins	3	5	15
Fire	3	5	15
Electricity	3	4	12
Toxic gases, chemicals	3	4	12
Defective equipment	3	4	12
Vibration	3	3	9
Solvent paints	2	4	8
Biological hazards	1	3	3

Table 5: The most prominent risk (15-25) in descending manner.

Hazards	Matrix indices
1. Noise	**20**
2. Slippery floors	**20**
3. Broken floors	**20**
4. Cement, concrete, sand dust	**20**
5. Heavy tools	**20**
6. Inappropriate working posture	**20**
7. Prolonged waking, standing	**16**
8. Hit by rapidly moving equipment	**15**
9. Extreme heat, cold	**15**
10. Varicose veins	**15**
11. Fire	**15**

Discussion

Due to the constant moving of workers and equipment, construction sites are prone to accidents (Rafindadi et al., 2022). Risk assessment and identification have a significant role in determining decisions about health and risk, including using personal protective equipment (PPE) and adopting healthy behaviors (Ellaban et a., 2020).

The present study was conducted on 208 construction workers; with mean age of 36.59±12.07. About 29% of workers were at secondary school and 27.9% were illiterate (Table 1). This was in agreement with an Egyptian study done by Abbas et al. (2013) but in contrast to an American study of Cavallari et al. (2019), where average workers ‘ age were 44 years old and all were graduated. These differences are due to different educational and job opportunities in developing versus developed countries.

The current study showed that the mean duration of work was 16.17±4.31

years, mean number of working hours/ day was 9.19±2.57, the most common tasks were concrete formation (30.28%), building (18.26%), blacksmithing and installation of scaffolding worker (7.21%) and (6.73%) respectively (Table 2), but the Egyptian study done by Mohamed (2017) showed that average years of work was 11.10 ± 7.44 years, and the types of works were 30% erection of steel, 19% digging, 18% construction, 17% builder, 16% painter, this may be explained different job tasks at different locations of buildings.

Noise was the most common physical hazard reported by workers (72.1%) (Table 3). According to a survey, compared to workers in other industries, construction workers in Washington state are five times as likely to file workers' compensation claims for hearing loss (Department of Environmental and Occupational Health Sciences, 2024).

In contrast an Italian study of Antonucci et al.)2010(and an Egyptian study of Ellaban et al. 20) 20(who reported a low percent of noise hazard at construction sites, and this may be due to safety isolation measures (as a protective equipment) taken by workers.

The most common mechanical hazards found in the studied group were trauma and injuries (46.6%) (Table 3) which agreed with the study done by Abbas et al.)2013(, which revealed that 46.2% of workers had mechanical occupational injuries which were upper and lower limbs, cuts/lacerations contusions and falls. Antonucci et al.)2010(from Italy reported that only 28.3% of the workers reported mechanical injuries during their working life. Dong)2005(found that approximately 11.5% of the construction workers in Hong Kong had a work-related mechanical injuries. These differences could be the result of stricter safety regulations, more stringent oversight of the workplace, and the use of personal protective equipment (PPE) in western nations. In the current study it could be the result of participants' younger ages, which puts them at higher risk of accidents. Furthermore, it seems that in affluent nations, building sites considered the health risks to their workforce.

There was a high percent of chemical hazards from cement, sand, concrete and toxic gases among the studied group (Table 3) which agreed with the study of Zuo et al. (2017) which showed that there is a significant

chance that construction site workers will breathe in contaminated air and have serious health issues.

For each identified hazard in the study; risk matrix for eighteen hazards was conducted one by one and reported in Table 4, however, through the study of Almaskati et al.2024(), lesser construction hazards were reported and categorized, this may be due to different tools of data collection.

The highest matrix indices in descending manner were for noise, slippery floors, broken floors, cement, concrete, sand dust, heavy tools and inappropriate working posture (Table 5).

Construction often results in noise pollution, which is characterized by unexpected, unpredictable severe, and challenging-to-control sound outbursts. It is mostly caused by impact-producing machinery like combustion engines, pile drives, and earth augers (Mir et al., 2023). This was in agreement with an American study of Cavallari et al.)2019(, showing that noise at construction sites is a highly ranked risk.

Falls were the primary risk for construction workers in many countries, including the United States, Singapore, New Zealand, Hong Kong, Taiwan, and Kuwait (Goh and Saadon, 2015). Regarding the current study, rank of both slippery floor and broken falls were high (Table 5), which was in accordance with Anantharaman et al. 2023( )who documented that falls are the most common type of construction accidents, with the majority of them happening at ground level (such as falls into holes and excavation pits) and from elevated positions (such as falls from scaffolding, roofs, ladders, and cranes).

The primary cause of slips, trips, and falls on the same level is the minimal friction between the foot and the walking surface. Other risk factors include environmental, systemic, and human factors. Unstable or uneven surfaces, pollutants on the walking surface as a result of improper cleaning, insufficient lighting, inappropriate footwear, and the inability to see the hazard are additional contributing factors (Sanni-Anibire et al., 2020).

Sand dust was a highly ranked risk as detected in the present study (Table 5), in contrast; Almaskati et al. (2024)found that asbestos dust was the highly ranked risk, the cause may be as in Egypt asbestos became prohibited in building industries.

Repetitive motions, such as handling materials and equipment, are responsible for ergonomic hazards that heighten the risk of developing musculoskeletal disorders (Quesada et al., 2020). Heavy tools and inappropriate working posture was a highly ranked risk (Table 5), which inconsistent with Mohamed (2017), as construction equipment and material handling encompass the movement of materials manually or mechanically through lifting, lowering, pushing, pulling, holding, and carrying.

Conclusion and Recommendations

Noise, slippery floors, broken falls, cement, concrete, sand dust, heavy tools and inappropriate working posture ranked the highest risk among construction and building workers. We recommend enhancing workers' interests in active safety management and implementation of awareness programs. An additional training for the workers, which could be provided by contractors about the use of protective equipment, would also would also help to minimize accidents. The suitable measures for prevention and control of the identified risk delivered to the project manager for monitoring and evaluation (the main aim of risk assessment).

Conflict of Interest

The authors declared that they have no conflict of interest.

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