

Factors and Method of Preventing Construction Site Incidents [†]

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Abstract: Construction accidents cause property damage and harm the environment. The construction industry in the UAE has recorded high fatalities and injuries. However, there has been limited research to prevent accidents on construction sites. Hence, this study aims to uncover the factors causing accidents and prevention measures. All the factors and prevention measures were identified through a literature review and verified in a questionnaire survey. A total of 50 incident causative factors were identified in two groups, and direct and underlying causes and six main preventive measures were determined. The questionnaire survey involved 30 experts who had 10 years of working experience in the UAE construction industry. The experts assessed each of the causative factors and the preventative measures based on a 5-point Likert scale. Reliability was tested on the collected data using Cronbach's alpha value, and the value was 0.977. The most severe relevant factors of direct causes included violation, taking shortcuts, inadequate leadership/supervision, and human errors. The probability and severity were moderate, and the hazardous activities included unsafe working at height and unsafe lifting. This study shows that workers with experience from 1 to 5 years were engaged in the most accidents. In total, 26 preventive measures were determined. The results benefit the construction industry of the UAE in preventing or avoiding potential accidents at construction sites.

Keywords: accidents; factors; prevention; measures; UAE



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1. Introduction

Buildings and infrastructure development are a part of the construction industry. The UAE has a strong economic foundation, and the construction industry is expanding. According to the United Nations Accounts Database, the UAE was ranked 18th out of 25 countries in the world for construction. It is mandated that all organizations establish a management system for occupational health and safety. Under the mandate, the Abu Dhabi Occupational Health and Safety (OSHAD) Center was established to formulate the requirements, practices, and guidelines for the establishment, implementation, and oversight of occupational health and safety. The most recent version of these guidelines was released in 2017.

The construction industry is one of the most hazardous industries in terms of occupational accidents [1]. There is still a dearth of detail in accident models and the factors for construction accidents. Effective prevention of accidents involves an understanding of significant factors [2]. The factors are interrelated with each other and cannot be isolated. However, there is still a need to realign and re-balance the priorities assigned to factors

to significantly improve safety on construction sites [3]. Duryan et al. [4] proved that workplace injuries and fatalities in the UK at construction sites have declined markedly since the occupational health and safety (OHS) management system was introduced [5]. The system summarizes frequent major risks, demanding scientific approaches for investigating fall-from-height incidents and intended preventive measures to enhance safety. Nevertheless, the accidents lack an assessment of the relationship between these factors. Organizational factors and shared values reflect the security perspectives of organization members [6].

Weiy and Jwong (2015) [7] researched safety management, concentrating on safety risk management, environment, behavior, system safety evaluation, and other topics that necessitate a large amount of objective and historical data, including risk analysis, management, and influence. Human beings are affected by safe environments and behavior. The construction industry in the USA implements the concept of designing construction safety as a standard practice to reduce overall project risks [8]. Construction is one of the riskiest jobs in the world. In 2009, the United States' fatal work-related injury rate for construction workers was three times higher than that of all other workers. The most common cause of injuries was falls from heights.

We carried out a literature review on occupational health and safety to determine related factors. As a result, 53 factors were defined in four categories. Protection equipment for safety, such as guardrails, hard hats, and harnesses, was also researched. Workplace accidents related to scaffolding can be prevented by using the right safety gear and practices, such as locking ladders and having scaffolding inspected by a qualified individual. In the construction industry, trench cave-ins, transportation accidents, and electrocution are the leading causes of fatal injuries. Given that construction works take place in dangerous surroundings, there are many causes of accidents. Accidents increase the costs of construction and negative publicity. Authorities have tightened safety regulations to improve safety on construction sites. However, accidents still occur, which necessitates more research.

Accidents in the construction industry are unanticipated. In construction projects, accident prediction is crucial [9]. In 2014, 4251 workers on private projects suffered fatal injuries, of which 874 were involved in a construction project, according to the United States Occupational Safety and Health Administration. In total, 5% of the occupational fatalities in the US occurred in the construction industry. Additionally, once engineers and designers are aware of the implications of occupational health and safety, key performance metrics for these areas can be improved. In the safety and health performance in the UAE, the design of safety and health measures reduces work-related injuries and related costs and improves work progress and personal protective equipment [10].

According to data from the UAE Labour Office in 2010, 40% of all employees were employed in the construction sector. There are three authorities for construction in the UAE: TRAKHEES, Dubai Municipality (DM), and the Dubai Technology and Media Free Zone Authority (DTMFZA). The authority has its jurisdiction and establishes rules and controls construction. Safety and health measures can be determined by designers, as workers' health and safety are the contractor's exclusive responsibility. Designers need to consider safety and health in the design process before the project starts [11]. Al Zarooni, Awad, and Alzaatreh [12] noted that research is necessary to understand how policies have affected industry sectors and work-related incidents. To determine common causes, linkages, and factors of construction accidents, the Labour Inspection Authority investigated 176 significant construction accidents using the construction accident causation (ConAC) method. Worker activities, risk management, immediate supervision, material or equipment usability, local dangers, worker capabilities, and project management were important factors.

Causal relationships between these factors were found using a set-theoretic method, risk management, direct supervision, and worker behaviors.

According to Gungor [13], safety signs are crucial for health hazards, fire safety, emergency evacuation, and accident avoidance. These factors are consistently associated with worker behaviors. A correlation between worker behavior, risk management, and immediate supervision was found, highlighting the supervisor's responsibility for dangerous situations or behaviors and organizing tasks to reduce risks. Planning and risk control at various levels are necessary for risk management and immediate supervision, underscoring the necessity of risk management [14].

The types of accidents are identified using construction accident investigation and reporting systems. However, a sufficient explanation for accident is lacking. Therefore, the theories of accident causes and human errors must be investigated. Due to the unique characteristics of the construction industry, human errors and accident causes must be understood.

The Accident Root Causes Tracing Model (ARCTM), created especially for the construction sector, was used in this study. According to ARCTM, there are three main reasons for accidents: (1) not identifying an unsafe condition that was present before or developed after an activity started; (2) carrying out work even after noticing an unsafe condition; and (3) acting unsafely despite the initial conditions. The ARCTM highlights how critical it is to comprehend unsafe conditions during work, attributing them to four primary causes: (1) mismanagement; (2) worker or colleague misconduct; (3) non-human-related incidents; and (4) an unsafe condition inherent to the original construction site. As a result, the ARCTM offers a comprehensive framework for understanding construction site accidents by acknowledging the possible contributions of both management and labor to the accident process. Preventative action is needed for efficient accident avoidance [15].

The social dynamics at work have an impact on industrial accidents. The sociological explanation is in opposition to safety procedures, which are related to risky behaviors and environmental factors in accidents. Accidents happen at the individual member level as well as at the social level at work. Data from a semi-experimental design were used to assess hypotheses, with variables including shift type (rotating/fixed), shift type (day/night), technology kind, and management styles. Social interactions varied, although the same workers worked in different shifts. The majority of the variations in accident rates between shifts were described by the sociological hypothesis, and statistical analyses indicated that it explains better than other theories. When workers lose orientation, accidents can be avoided by safety management, as described by sociology and by self-control. When making changes to ergonomics, how the workspace's machinery, plant, and procedures interact with the social dynamics of the workplace must be explained. Social knowledge ought to be incorporated into the ergonomics [16].

Construction-related accidents are a major problem. In Australia, variables and interactions in construction investigations were determined. We examined the contributing variables, preventive measures, and factors in 100 construction accident investigation reports by applying a thematic analysis. We assessed how well they matched up with current theories of accident occurrence. The investigation of construction accidents concentrated on human mistakes to uncover contributing factors and their interactions. The study results highlighted the advantages of using theory-based techniques for accident investigation and analysis as well as significant ramifications [17]. Recently, there has been a noticeable decrease in occupational accidents in the construction industry. Nonetheless, the death toll is still higher than in other industries. Previous research provided analytical models to determine factors of occupational accidents and the causes of accidents. A novel model was constructed by studying various projects and surveying design and site supervision. A thorough analysis of the factors included the state of the economy, the skill of the design

team, project and risk management, financial capability, health and safety regulations, and early planning for effective risk prevention [18].

It has been normal practice to avoid construction accidents using the behavior-based approach. Nevertheless, the effects of these treatments did not have advantages. Instead of concentrating on the immediate causes of accidents, systemic variables need to be determined. By examining heat sickness on construction sites, a causal relationship between construction accidents and illnesses was found. In heating sickness, a person is partially the agent and the sufferer. Even though it has the potential to be lethal, the effect affects the afflicted person only and does not spread to others. To determine institutional factors that affect construction accidents in construction, a simplified example of heat sickness was studied. In 36 heat sickness incidents, 216 individual patients from 29 construction sites were interviewed, and site observations were conducted. The study revealed institutional characteristics to support behavioral interventions to prevent heat sickness. The results provided efficient interventions and elements to be improved [19].

A study examining one hundred distinct construction incidents was carried out with focus groups. Qualitative information on the circumstances in each incident and the contributing elements were studied. Interviews with accident participants and their managers or supervisors, site inspections, and evaluations of pertinent records were conducted. For site investigations, stakeholders including designers, manufacturers, and suppliers were consulted. Problems with employees or work groups accounted for 70% of the causes of the accidents. Workplace-related concerns accounted for 49%; equipment flaws accounted for 56% of the accidents; difficulties with material appropriateness and condition accounted for 27% of the accidents; and inadequate risk management for 84%.

A model of an ergonomic system showed how management, design, and cultural elements affected circumstances and behaviors in accidents. For long-term construction safety, it is imperative to address worker issues (unsafe acts/personal factors), workplace issues (unsafe condition factors), equipment/material issues (unsafe condition factors), and management concerns (system factors), which are the categories into which the causal elements of accidents fall. To test a prospective analytic approach of the UK Health and Safety Executive (HSE) Construction Division, a small sample of fatal construction incidents was studied. This study was conducted as a government inquiry. Out of 211 fatal incidents between 2006 and 2008, 26 occurrences (resulting in 28 fatalities) were included. These accidents were chosen to reflect a variety of accident characteristics. Structured interviews with the investigating inspectors and the inspectorate reports were used to assess the accidents. A systematic categorization was carried out using the Human Issue Analysis and Categorization System (HFACS), covering organizational and task-level issues in addition to mistakes. The results described underlying issues associated with shortcomings in design, procurement and installation, competence assurance, planning and risk assessment, and contracting techniques. By comparing the findings with fifty incidents, the results were verified [20].

Project management involves managing a temporary project team to achieve objectives related to cost, quality, function, and utility throughout all stages of a project's life cycle by applying fundamental management in planning, organizing, controlling, and leading. Rather than being a fundamental idea, worker safety is frequently seen as an external factor in project management. Planning and environmental restrictions, codes of conduct, labor laws, safety rules, licenses, insurance, and tax laws play a significant role in the construction industry. Since most of these rules and regulations are well stated, it is possible to estimate how they will affect building projects with a fair degree of accuracy. However, it is typical for industrial, safety, tax, and environmental rules to change regularly due to difficulties in

law changes and projects. The principal contractor's major responsibility is to oversee the work of subcontractors.

The construction site is a crucial resource, similar to labor, equipment, materials, and time, and resource allocation is a vital part of construction planning. The construction plan aims to optimize the site by strategically placing facilities in available locations. An effective site layout shortens transportation time, reduces the frequency of material transport, minimizes material re-handling, lowers labor costs, and consequently reduces construction costs. By reasonably assigning construction operation and areas, auxiliary operational areas, and material laydown areas within the site layout plan, conflicts between workers and facilities, between different facilities, between workers and the environment, and between facilities and the environment must be avoided to ultimately enhance the safety level of the construction site.

2. Methodology

A questionnaire was developed for the objectives of this research. The outcome of the literature review was used to develop the questionnaire. It was distributed to construction experts in Abu Dhabi, the UAE, who had more than 5 years' experience [21]. Four useful recommendations were given in the questionnaire, which consisted of three parts: demography, factors affecting accidents, and prevention measures. In the demography part, the profile of respondents included company category, types of accidents, age, and working experience. Factors of accidents were extracted from the literature review. Preventive measures were also listed based on the results of the literature review (Table 1).

Table 1. Factors affecting accidents.

Q	Part B: What is Your Scale for the Following Management System Factors that Cause the Incident Do You Experience?	Q48	Excessive Noise Exposure
Q1	Inadequate training	Q49	Radiation exposure
Q2	Inadequate/missing procedure	Q50	Equipment failure
Q3	Inadequate purchasing/material handling	What is your scale for the following nature of incident do you experience?	
Q4	Inadequate tool/ marital	Q51	Abrasions/Bruising (Scratches)
Q5	Inadequate risk assessment/management	Q52	Amputation—Traumatic
Q6	Inadequate contractor management	Q53	Burn
Q7	Inadequate management of change	Q54	Crush Cuts/Laceration/Open Wound
Q8	Inadequate leadership/supervisor	Q55	Electric Shock
Q9	Inadequate incident investigation/analysis	Q56	Foreign Body under Skin
Q10	Inadequate engineering/design/control	Q57	Fracture
Q11	Inadequate maintenance	Q58	Foreign Body in Eye
Q12	Inadequate communication	Q59	Heat-Related Illness
Q13	Inadequate planning/inspection	Q60	Occupational Illness/Disease
Q14	Inadequate emergency response plan	Q61	Psychological (Stress).
	What is your scale for the following Personal factors that cause the incident do you experience?	Q62	Poisoning/Toxic Effect—Inhalation

Table 1. Cont.

Q	Part B: What is Your Scale for the Following Management System Factors that Cause the Incident Do You Experience?	Q48	Excessive Noise Exposure
Q15	Physical capability	Q63	Strain/Sprain
Q16	Mental state	Q64	Respiratory Disease
Q17	Behavior	Q65	Skin Irritation/Disease
Q18	Human error	What is your scale for the following mechanism of incident/injury that causes the incident do you experience?	
Q19	Physical condition	Q66	Human–Human
Q20	Skill level	Q67	Confined Space
Q21	Mental stress	Q68	Environmental Conditions
What is your scale for the following unsafe acts that cause the incident do you experience?		Q69	Fixed Machinery
Q22	Failure to secure its	Q70	Infectious Agent
Q23	Failure to warn	Q71	Materials or Chemical Substances
Q24	Remove/Defeating safety device	Q72	Mobile Plant/Equipment
Q25	Failure to use PPE	Q73	Non-Powered Equipment/Tools/Appliances
Q26	Operation at improper speed	Q74	Scaffolding or Ladders
Q27	Lack of awareness/knowledge	Q75	Powered Equipment/Tools/Appliances
Q28	Lack of attention concentration	Q76	Road Transport/Vehicles at site
Q29	Violation/taking shortcuts	Q77	Sharps/Scalpels/Needles/etc.
Q30	Operation equipment without authority	Q78	Trench or Excavations
Q31	Service equipment in operation	What is your scale for the following body parts that was affected incident do you experience?	
Q32	Using defective equipment/tools	Q79	Head
Q33	Using equipment improperly	Q80	Spine, Pelvis, and Back
Q34	Improper lifting/ lading/ placement	Q81	Fingers and Thumb
Q35	Improper position for task	Q82	Toe, Foot, and Ankle
Q36	Horseplay	Q83	Heat-Related and Occupational Illness
What is your scale for the following unsafe conditions that cause the incident do you experience?		Q84	Eye
Q37	Inadequate guards or barriers	What is your scale for the following top hazard in construction site do you experience?	
Q38	Inadequate wiring system or notice	Q85	Unsafe working at height
Q39	Inadequate ventilation	Q86	Unsafe lifting operation
Q40	Fire and explosive hazard	Q87	Open shafts & edges
Q41	High/low temperature exposure	Q88	Unsafe machine/equipment/tools

Table 1. Cont.

Q	Part B: What is Your Scale for the Following Management System Factors that Cause the Incident Do You Experience?	Q48	Excessive Noise Exposure
Q42	Hazardous gases/dust/vapors/fumes	Q89	Housekeeping/site store
Q43	Defective tools, equipment or material	Q90	Unsafe working platforms/ladder/cantilever/scaffolds
Q44	Inadequate or improper protective equipment	Q91	Unsafe excavation
Q45	Inadequate or excess illumination	Q92	Unsafe electrical equipment/connection
Q46	Congestion/ restricted action/poor access	Q93	What is the probability of incident do you experience?
Q47	Poor housekeeping, disorder	Q94	What is the severity of consequence of the incident do you experience?
	How do you scale the following managing incident prevention factors?		Part C: What is your scale for the following incident prevention method (task factors) do you experience??
Q95	Top management commitments, leadership, and lead by example policy	Q109	Use of safe work procedure
Q96	Sufficient training (induction, orientation, awareness and specific training)	Q110	Applying work safe monitoring procedure
Q97	Safe work procedures being enforced for implementation	Q111	Safety devices exciting (human error prevention method)
Q98	Adequate supervision	Q112	Appropriate tools and materials
Q99	Carry out regular maintenance of equipment.		What is your scale for the following incident prevention method (material) do you experience?
Q100	Regular safety joint inspections (CEO, Director, GM, PM, CRE, and supervisor)	Q113	Appropriate equipment and machinery
Q101	Committed to risk assessment and management of change	Q114	Less hazardous alternative products (possible and available)
Q102	Implementation of Hazard, Near Miss, Incident Reporting, and Investigation.		What is your scale for the following incident prevention method (work environment factors) do you experience?
Q103	Committed consultation and communication procedure.	Q115	Poor housekeeping
Q104	Incident investigation led by top management and corrective action implemented.	Q116	Physical work environment (noise, temperature, light, weather, ...)
	What is your scale for the following incident prevention method (personnel factors) do you experience?		What is your scale for the following incident prevention method (PPE) do you experience?
Q105	Implementing competency procedure	Q117	Use of proper head protection.
Q106	Implementing roles and responsibilities procedure	Q118	Use of proper coverall protection.
Q107	Physical and mental capability, and workload	Q119	Use proper foot protection.
Q108	Follow the safe operating procedures	Q120	Use of proper eye protection.

3. Results

The measurement scale was used to measure the level of relevancy of the factors, the nature of the incident, the body part affected by the incident, and prevention measures. Table 2 presents the scale used in the survey [22].

Table 2. Scale in questionnaire.

Scale	1	2	3	4	5
Description of the scale	Not significant (0%)	Slightly significant (25%)	Moderately significant (50%)	Significant (75%)	Very Significant (100%)

The questionnaire's content was validated using the method in Refs. [23,24]. Hill [25] and Isaac and Michael [26] included 10 to 30 respondents in their research. Van Belle [27] included 12 volunteers for their research. In this study, the semi-structured questionnaire survey was carried out for contractors, consultants, and others who had more than 5 years of experience in the UAE. In the survey, the respondents responded online, on the telephone, and via email [26–32]. A total of 30 respondents were included in the survey, with a return rate of 88% (Table 3).

Table 3. Respondents and scoring scale.

Likert's Relevancy Scale				
Number of Questions	Level of Relevancy	%	Likert's Relevancy Scale	Number of Answers
120	Extremely relevant	100	5	0
	Very Relevant	75	4	31
	Moderately Relevant	50	3	61
	Slightly Relevant	25	2	28
	Not relevant	0	1	0
				120

3.1. Reliability Test

The reliability test results of the 126 items in the questionnaire are displayed in Table 4. Cronbach's alpha value was calculated for the test. Cronbach's alpha values were higher than 0.9, indicating legitimacy [33]. The questionnaire had internal consistency, too.

Table 4. Reliability of questionnaire survey.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.977	0.975	126

3.2. Descriptive Statistics

The demography of the respondents is described in Figure 1. The majority (83.3%) held a degree or postgraduate certification, whilst 16.6% had advanced diplomas. Given that the majority of respondents had a decent level of expertise, the questionnaire responses were regarded as reliable. In total, 43.3% of the respondents had experience with occupational safety and health in the construction business, whereas 56.7% had been employed for 11 to 20 years.

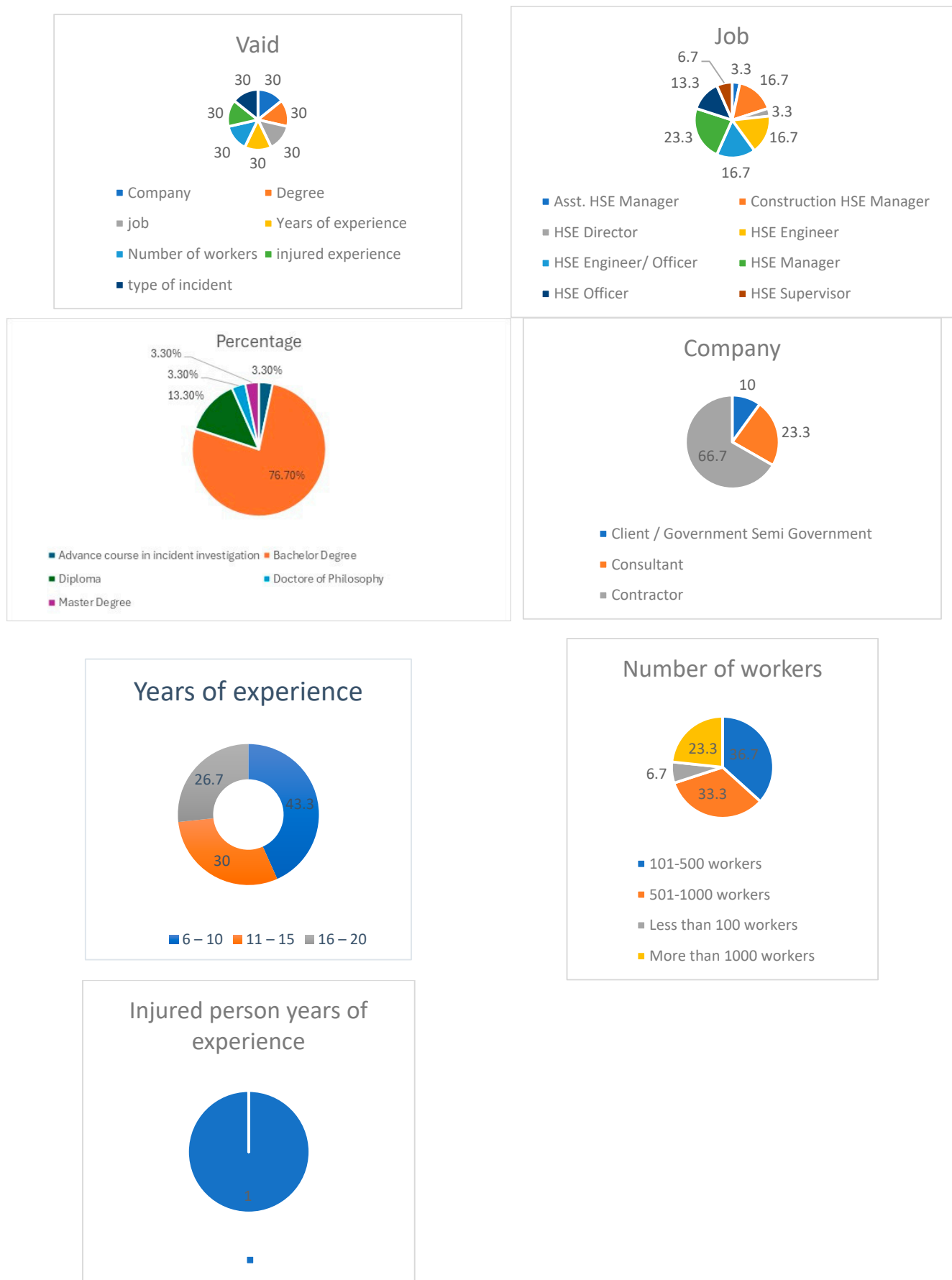


Figure 1. Descriptive statistics of questionnaire survey results.

3.3. Factors and Preventive Measures

Q20 had a p -value of 0.039, and Q57 had 0.031, so they were not statistically significant. Other items were significant statistically. There were 27 slightly relevant factors, 62 moderately relevant factors, and 5 factors that were relevant, while there were no irrelevant or extreme factors, as shown in Table 5.

Table 5. Factors affecting accidents on construction sites.

Q	p Value [Cut off Value Is 0.05]	Mean Score	Level of Relevancy	Q	p Value [Cut off Value Is 0.05]	Mean Score	Level of Relevancy
Q1	0.197	3	Moderately relevant	Q48	0.727	2	Slightly relevant
Q2	0.997	3	Moderately relevant	Q49	0.8.2	2	Slightly relevant
Q3	0.062	3	Moderately relevant	Q50	0.924	3	Moderately relevant
Q4	0.477	3	Moderately relevant	Q51	0.400	3	Moderately relevant
Q5	0.306	3	Moderately relevant	Q52	0.677	2	Slightly relevant
Q6	0.258	3	Moderately relevant	Q53	0.737	2	Slightly relevant
Q7	0.121	3	Moderately relevant	Q54	0.851	3	Moderately relevant
Q8	0.329	4	Very relevant	Q55	0.920	2	Slightly relevant
Q9	0.691	3	Moderately relevant	Q56	0.340	2	Slightly relevant
Q10	0.508	3	Moderately relevant	Q57	0.031	3	Moderately relevant
Q11	0.510	3	Moderately relevant	Q58	0.852	2	Slightly relevant
Q12	0.192	3	Moderately relevant	Q59	0.626	3	Moderately relevant
Q13	0.795	3	Moderately relevant	Q60	0.525	2	Slightly relevant
Q14	0.962	3	Moderately relevant	Q61	0.132	2	Slightly relevant
Q15	0.849	2	Slightly Relevant	Q62	0.802	2	Slightly relevant
Q16	0.975	2	Slightly Relevant	Q63	0.844	2	Slightly relevant
Q17	0.643	3	Moderately relevant	Q64	0.486	2	Slightly relevant
Q18	0.820	4	Very relevant	Q65	0.390	2	Slightly relevant
Q19	0.474	2	Slightly relevant	Q66	0.258	3	Moderately relevant
Q20	0.039	3	Moderately relevant	Q67	0.780	2	Slightly relevant
Q21	0.822	3	Moderately relevant	Q68	0.203	2	Slightly relevant
Q22	0.097	3	Moderately relevant	Q69	0.062	2	Slightly relevant
Q23	0.355	3	Moderately relevant	Q70	0.368	2	Slightly relevant

Table 5. Cont.

Q	<i>p</i> Value [Cut off Value Is 0.05]	Mean Score	Level of Relevancy	Q	<i>p</i> Value [Cut off Value Is 0.05]	Mean Score	Level of Relevancy
Q24	0.968	3	Moderately relevant	Q71	0.259	2	Slightly relevant
Q25	0.228	3	Moderately relevant	Q72	0.337	3	Moderately relevant
Q26	0.281	3	Moderately relevant	Q73	0.207	3	Moderately relevant
Q27	0.947	3	Moderately relevant	Q74	0.073	3	Moderately relevant
Q28	0.768	3	Moderately relevant	Q75	0.333	3	Moderately relevant
Q29	0.992	4	Very relevant	Q76	0.296	3	Moderately relevant
Q30	0.581	3	Moderately relevant	Q77	0.897	3	Moderately relevant
Q31	0.819	3	Moderately relevant	Q78	0.475	3	Moderately relevant
Q32	0.763	3	Moderately relevant	Q79	0.751	2	Slightly relevant
Q33	0.326	3	Moderately relevant	Q80	0.527	2	Slightly relevant
Q34	0.767	3	Moderately relevant	Q81	0.581	3	Moderately relevant
Q35	0.812	3	Moderately relevant	Q82	0.932	3	Moderately relevant
Q36	0.487	3	Moderately relevant	Q83	0.224	3	Moderately relevant
Q37	0.433	3	Moderately relevant	Q84	0.435	2	Slightly Relevant
Q38	0.458	3	Moderately relevant	Q85	0.097	4	Very relevant
Q39	0.204	2	Slightly relevant	Q86	0.579	4	Very relevant
Q40	0.254	2	Slightly relevant	Q87	0.942	3	Moderately relevant
Q41	0.768	3	Moderately relevant	Q88	0.087	3	Moderately relevant
Q42	0.336	2	Slightly relevant	Q89	0.359	3	Moderately relevant
Q43	0.701	3	Moderately relevant	Q90	0.207	3	Moderately relevant
Q44	0.304	3	Moderately relevant	Q91	0.777	3	Moderately relevant
Q45	0.452	2	Slightly relevant	Q92	0.409	3	Moderately relevant
Q46	0.905	3	Moderately relevant	Q93	0.053	3	Moderately relevant
Q47	0.290	3	Moderately relevant	Q94	0.438	3	Moderately relevant

The incident preventive measures had no statistically significant difference in the years of working experience, and all of them were scored higher than 4 (extremely relevant), as shown in Table 6.

Table 6. Preventive measures and their scores.

Factors	<i>p</i> Value [Cut off Value Is 0.05]	Factors	<i>p</i> Value [Cut off Value Is 0.05]
Q95	0.533	Q108	0.179
Q96	0.903	Q109	0.307
Q97	0.689	Q110	0.882
Q98	0.376	Q111	0.149
Q99	0.616	Q112	0.957
Q100	0.550	Q113	0.825
Q101	0.340	Q114	0.526
Q102	0.326	Q115	0.081
Q103	0.781	Q116	0.627
Q104	0.387	Q117	0.856
Q105	0.372	Q118	0.974
Q106	0.530	Q119	0.529
Q107	0.110	Q120	0.697

A Kruskal–Wallis H Test was conducted for the 30 respondents. Between the three groups of different experiences, there was no statistically significant difference (p -value > 0.05). The mean score was higher than 3 (moderately relevant). Table 7 shows the relevancy of the factors in the expert's opinions.

Table 7. Relevancy of factors affecting accidents in expert's opinions.

Likert Scale	Management System Factors	Personal Factors	Unsafe Act	Unsafe Condition
1	N/A	N/A	N/A	N/A
2	N/A	- Physical Capability - Mental state - Physical condition	N/A	- Inadequate ventilation - Fire and explosive hazard - Hazardous gases/ dust/vapors/ fumes - Inadequate or excess illumination - Excessive noise exposure - Radiation exposure
3	- Insufficient instruction; inadequate or absent protocol - Poor material handling and purchase—poor tool/material - Poor risk assessment and management; poor contractor management; poor change management - Insufficient examination and analysis of the incident Inadequate emergency response plan; inadequate planning and inspection; inadequate communication; inadequate maintenance; inadequate engineering, design, and control;	- Behavior - Skill level - Mental stress	- Not securing; not warning; eliminating or circumventing safety device - Not wearing personal protective equipment (PPE); operating at the incorrect pace - Absence of awareness or understanding; inability to focus attention - Using faulty tools or equipment; operating equipment without authorization; improperly placing, lifting, or loading equipment; positioning equipment incorrectly for a purpose; horseplay	- Insufficient barriers or guards - Inadequate notice or wiring system; exposure to extreme temperatures - Defective apparatus, material, or tool; insufficient or inappropriate personal protective equipment; congestion, restricted movement, or inadequate access; poor housekeeping or disorder - Equipment malfunction
4	- Inadequate leadership/ supervisor	Human error	- Violation/taking shortcuts	N/A
5	N/A	N/A	N/A	N/A

In total, 26 methods for incident prevention were identified and were relevant. The methods were grouped into management, personal, task, material, work environment, and personal protective equipment, as shown in Table 8.

Table 8. Preventive measures.

Likert Scale	Management	Personal	Task	Material	Work Environment	PPE
1	N/A	N/A	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A	N/A	N/A
4	1—Top management commitments, leadership, and lead by example policy 2—Sufficient training (induction, orientation, awareness and specific training) 3—Safe work procedures being enforced for implementation 4—Adequate supervision 5—Carry out regular maintenance of equipment 6—Regular safety joint inspections (CEO, Director, GM, PM, CRE, and supervisor) 7—Committed to risk assessment and management of change 8—Implementation of Hazard, Near Miss, Incident Reporting, and Investigation. 9—Committed consultation and communication procedure. 10—Incident investigation led by top management and corrective action implemented.	11—Implementing competency procedure 12—Implementing the roles and responsibilities procedure 13—Physical and mental capability and workload 14—Follow the safe operating procedures	15—Use of safe work procedure 16—Applying work safe monitoring procedure 17—Safety devices exciting (human error prevention method) 18—Appropriate tools and materials	19—Appropriate equipment and machinery 20—Less hazardous alternative products (possible and available)	21—Poor housekeeping 22—Physical work environment (noise, temperature, light, weather, ...)	23—Use of proper head protection. 24—Use of proper coverall protection. 25—Use of proper foot protection. 26—Use of proper eye protection.
5	N/A	N/A	N/A	N/A	N/A	N/A

The hazard relevancy of the accidents in the construction industry is shown in Table 9.

Table 9. Relevancy of factors to accidents.

Likert Scale	Top Hazard
1	N/A
2	N/A
3	- Open shafts and edges - Unsafe machine/equipment/tools - Housekeeping/site store - Unsafe working platforms/ladder/cantilever/scaffolds - Unsafe excavation - Unsafe electrical equipment/connection
4	- Unsafe working at height - Unsafe lifting operation
5	N/A

The risk evaluation and assessment for the construction site showed moderate relevancy (Table 10).

Table 10. Relevancy of risk evaluation.

Risk Evaluation					
Likert Scale	1	2	3	4	5
Probability			✓		
Severity			✓		

The factors affecting the accidents, the nature of the accidents, and related body parts are shown in Table 11.

Table 11. Relevancy of accident nature, mechanism, and related body parts.

Likert Scale	Nature of the Accidents		Mechanism	Body part
1	NA		NA	NA
2	- Amputation—Traumatic - Burn—Electric Shock - Foreign Body under Skin - Foreign Body in Eye - Occupational Illness/Disease - Psychological (Stress) - Poisoning/Toxic - Effect—Inhalation - Strain/Sprain - Respiratory Disease - Skin Irritation/Disease	- Confined Space - Environmental Conditions - Fixed Machinery - Infectious Agent - Materials or Chemical Substances	- Head - Spine, Pelvis, and Back - Eye	
3	- Abrasions/Bruising (Scratches) - Crush Cuts/ Laceration/Open Wound - Fracture - Heat-Related Illness	Human—Transportable Plant/Equipment - Non-Powered Tools, Appliances, and Equipment - Ladders or scaffolds - Powered Tools, Appliances, and Equipment - Road Transport and On-Site Vehicles - Needles, scalpels, sharps, etc. - Digging or excavating	- Fingers and Thumb - Toes, Foot, and Ankle - Heat-Related and Occupational Illness	
4	NA		NA	NA
5	NA		NA	NA

4. Conclusions

A total of 92 factors were determined for accidents on construction sites in the UAE in immediate and root causes. The immediate causes were grouped into safe (15 factors) and unsafe conditions (14 factors), while the root causes were grouped into personal factors (7) and system factors (15). Seven causative factors such as direct supervision and local hazards were linked to worker behaviors. There was a substantial correlation between worker behaviors, risk management, and immediate supervision. The results highlight the significance of the supervisor's management of dangerous conditions/acts and the organization of the jobs to minimize risk. A strong correlation was revealed between worker behaviors and risk management, as well as between risk management and timely monitoring. The significance of risk must be addressed at different levels and by different behaviors in construction projects because risk management and immediate supervision are important in risk control at different levels. Correlations between the causative elements were also observed. To effectively prevent accidents, factors related to requirements, the state of the economy, the skill of the design team, project and risk management, financial capacity, health and safety policy, and early planning must be assessed.

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