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Significant Safety Factors Affecting the Safety Performance in Iraqi Construction Projects

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ABSTRACT

Despite recent attempts to improve safety in the construction sector, this sector is considered dangerous and unsafe. Iraq is one of the emerging nations that suffers from a lack of construction safety management. In 2018, the construction sector in Iraq was responsible for 38% of all industrial accidents. Creating a safety program minimizes this problem by making safety an intrinsic part of construction projects. As a result, this article aims to identify the crucial safety factors that affect the safety performance in Iraqi construction projects. After conducting a critical literature review of the related literature, a list of 35 sub-factors classified into nine categories of main factors was chosen to rank each factor according to significance. A total of 100 sets of questionnaires were delivered to respondents in various construction projects. It was discovered that the "Management Practices" factor was considered the most key safety performance factor among all the main factors. The results also showed that among all the sub-factors, "Personal protective equipment," "First aid and medical care," and "Contractor's site safety program" were considered the most influential sub-factors. Furthermore, "drug and alcohol tests for workers" are the least important safety sub-factors. On the other hand, five sub-factors were excluded as being unimportant and not affecting safety performance.

Keywords: Safety Factors, Safety performance, Construction projects, Iraq

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عوامل السلامة المهمة التي تؤثر على أداء السلامة في المشاريع الإنشائية العراقية

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الخلاصة

على الرغم من المحاولات الأخيرة لتحسين السلامة في القطاع الإنشائي، إلا أن هذا القطاع يعتبر خطيرًا وغير آمن. العراق من الدول الناشئة التي تعاني من نقص في إدارة سلامة الإنشاء. في عام 2018، كان قطاع الإنشاء في العراق مسؤولاً عن 38٪من الحوادث من بين بقية الحوادث الصناعية. يعد إنشاء برنامج السلامة إحدى الاستراتيجيات للتخفيف من هذه المشكلة من خلال جعل السلامة جزءًا لا يتجزأ من المشاريع الإنشائية. بالنظر إلى هذا الموقف، تهدف هذه الورقة إلى تحديد عوامل السلامة المهمة التي تؤثر على أداء السلامة في المشاريع الإنشائية العراقية. بعد إجراء مراجعة نقدية للأدبيات ذات الصلة، تم تحديد قائمة من 35 عاملًا فرعيًا مصنفة في 9 فئات من العوامل الرئيسية لترتيب كل عامل وفقاً لأهميته. تم تسليم ما مجموعه 100 مجموعة من الاستبيانات للمشاركين في المشاريع الإنشائية المختلفة. لقد وجد أن عامل "ممارسات الإدارة" يعتبر أهم عامل أداء للسلامة من بين جميع العوامل الرئيسية. وأظهرت النتائج أيضًا أنه من بين جميع العوامل الفرعية، كانت "معدات الحماية الشخصية" و "الإسعافات الأولية والرعاية الطبية" و "برنامج سلامة موقع المقاول" من أكثر العوامل الفرعية تأثيرًا. علاوة على ذلك، تعتبر "اختبارات تعاطي المخدرات والكحول للعاملين" أقل عوامل السلامة الفرعية أهمية. من ناحية أخرى، تم استبعاد خمسة عوامل فرعية باعتبارها غير مهمة ولا تؤثر على أداء السلامة.

الكلمات المفتاحية:عوامل السلامة، أداء السلامة، المشاريع الإنشائية، العراق.

1. INTRODUCTION

The construction industry has always been regarded as one of the most dangerous sectors in the world **(Son, 2022)**. There are various advantages to improving construction safety, including fewer disputes, cheaper costs and compensation, fewer delays, increased production and profitability, and saving human lives. The fast development of new technology has resulted in quick changes in our society and working environments, as well as increased complexity and changes in accident causes **(Shaikh et al., 2021).** Accidents at work result in the loss of lives, money, and equipment, often creating interruptions **(Rasheed, 2016).** Construction has one of the worst safety records among other industries, and it must find a new method to improve its reputation **(Nabi et al., 2020).**

The construction industry has a high rate of occupational accidents and fatalities, which is a significant global concern **(Chen et al., 2020)**. According to the International Labour Organization (ILO), about 2.78 million people die each year because of work-related occupational accidents or diseases, and 374 million people suffer non-fatal work-related injuries and illnesses. Construction sites are responsible for at least 108,000 fatalities annually, or 30% of all occupational fatalities. In some developed countries, construction workers are 3–4 times more likely than other employees to die in workplace accidents, but in developing nations, the dangers associated with construction employment maybe 3–6 times higher**(ILO, 2022).**

Iraq is making significant progress as a growing nation, particularly in rehabilitating cities that recovered from terrorists during the previous three years, where thousands of small and medium-sized service projects were carried out **(Hatem, 2019)**. Construction safety management in Iraq is plagued by a high incidence of construction accidents, resulting in a higher number of injuries and fatalities. **(Atta and Curtis, 2015)** believe that working conditions for workers in Iraq do not meet norms, particularly regarding health and safety procedures. This might be related to Iraqi construction projects' conventional method of managing Occupational Safety and Health OSH **(Saeed et al., 2021)**. The Iraqi construction sector has poor safety performance, and creating a safety program is one strategy to alleviate this problem by making safety an intrinsic part of construction projects. In 2018, the construction sector in Iraq was responsible for 38% of all industrial accidents **(Buniya et al., 2021)**.

As a result, this article aims to identify the crucial safety factors that affect safety performance in Iraqi construction projects and to illuminate management's responsibility for proactively implementing an efficient program to improve safety at construction sites. The authors also believe that the findings might be applied to choose the most active elements of health and safety programs, especially in developing countries such as Iraq.

2. SAFETY PERFORMANCE FACTOR

The Safety program is a proactive technique for improving construction sites' safety performance **(Son, 2022)**. Safety programs are required to decrease accident and injury rates by ensuring workers have a safe workplace and fostering a safety culture inside the company **(Othman et al., 2020)**.To improve safety performance, various safety programs and practices may be used. Other indicators can be used to choose and create a construction safety program **(Bavafa et al., 2018)**.

Occupational health and safety are key in all branches of industry, particularly in the construction industry. Even though the construction industry is constantly changing due to new techniques, equipment, and equipment, it is never without safety issues, including fatalities. As a result, health and safety issues are always key concerns in the construction industry, particularly issues related to poor safety performance, such as accidents and illnesses **(Wong and Soo, 2019)**.

Safety management is essential for improving the construction industry's future **(Jia et al., 2022)**. This includes several activities to develop, monitor, and manage occupational hazards in the industry and mitigate and protect against them. Despite these efforts, the construction industry is nevertheless plagued by high rates of occupational accidents worldwide. Therefore, improving safety management requires identifying and grasping the factors that impact construction safety performance **(Rivera et al., 2021)**.

Based on a literature review, the authors identified 35 subfactors classified into 9 categories of factors. In **Table 1**, these factors with their references are summarized.

3. RESEARCH METHODOLOGY

3.1 Data Collection

Based on a critical review of relevant literature on the factors that affect safety and health performance in worldwide construction projects, the authors identified 35 subfactors classified into 9 factors. Questionnaire surveys were used to collect the study's leading data. An open-ended questionnaire was designed and divided into three sections.

Table 1. Main and sub-factors influencing safety performance.

Main factors	Sub-factors	Source
Management Practices	Contractor's site safety program. Sub-contractor's site safety program. Drug and alcohol tests for workers. Accident investigation program. Housekeeping program. Personal protective equipment (PPE). Construction plant and equipment management. Emergency response plan. First aid and medical care. Utilizing technology.	**(Hallowell et al., 2013; Amiri et al., 2017; Awolusi and Marks, 2017; Bavafa et al., 2018; Mohammadi et al., 2018)**
Safety Training	Safety training course for all workers. Toolbox. Safety training for designers. Safety training for supervisors	**(Ning et al., 2010; Ismail et al., 2012; Wong and Soo, 2019; Rivera et al., 2021)**
Safety Commitment	Management's safety commitment. Owner's safety commitment. Financial resource allocation for safety. Management and personnel responsibilities definition relating to safety.	**(Liu et al., 2017; Bavafa et al., 2018; Wong and Soo, 2019; Rivera et al., 2021)**
Safety Audits and inspections	Contractor Auditing Program. Regular safety inspections. Safety risk identification.	**(Mahmoudi et al., 2014; Bavafa et al., 2018; Mohammadi et al., 2018; Feng and Trinh, 2019; Wong and Soo, 2019; Yap and Lee, 2020)**
Safety in Design	Safety commitment among designers. Engaging safety professionals to review the design. Communicating safety requirements to the designer.	**(Rajendran and Gambatese, 2009; Bong et al., 2015; Liu et al., 2017; Feng and Trinh, 2019; Yap and Lee, 2020)**
Safety In Contracts	Safety requirements in the contract. Safety and health risk identification in the construction drawings. The owner approved the contractor's safety plan. Offering material safety data sheets. High-standard safety policies.	**(Rajendran and Gambatese, 2009; Bavafa et al., 2018; Karakhan et al., 2018; Abdul Nabi et al., 2020)**
Contractor Selection	Contractor selection by owner. Subcontractors' selection by contractor.	**(Hinze and Gambatese, 2003; Rajendran and Gambatese, 2009;**

		Mohammad et al., 2018; Yap and Lee, 2020)
Employee Involvement	Set up a safety committee. Safety Supervisor Appointment.	**Rajendran and Gambatese, 2009; El-Nagar et al., 2015; Liu et al., 2017; Karakhan et al., 2018)**
Safety Incentive	Contractor safety rewards and punishment programs. Sub-contractor safety rewards and punishment programs.	**(Mohammad et al., 2018; Al-Aubaid et al., 2019; Yap and Lee, 2020; Rivera et al., 2021; Jia et al., 2022)**

The questionnaire's first part includes demographic data about the intended respondents. The second part of the questionnaire was devoted to information about the construction projects, such as the project name, the name of the executing company, and other information. The third section used a rating scale method based on a 5-point Likert scale to determine the importance of each safety performance factor and subfactor. One was defined as very unimportant, and five was described as very important. Before distributing the main questionnaire, a pilot survey form was sent to 3 construction safety experts and two academic researchers, and they were asked to review the draft survey form and provide their feedback, including on the questions' wording, clarity, and applicability of the alternatives offered for the survey questionnaire's development.
One hundred sets of questionnaires were delivered to respondents in various construction projects, where 56 questionnaires were disseminated via Google Forms, and 44 questionnaires were distributed manually. Google Forms were used to prepare the questionnaire. This method has been utilized to facilitate distribution to specialists. One of the most essential features of Google Forms is the ease with which the questionnaire can be delivered.

3.2 Data Analysis Techniques

3.2.1 Mean Analysis

The Factor Analysis was used for the mean score analysis to determine and elicit the main factors and subfactors impacting the safety performance of construction projects in Iraq. This method was applied to rank the mean results. T data sample and the study's measurements were described using descriptive statistics with Eq.(1) **(Scheaffer et al., 2010)**.

$$\bar{x} = \frac{\Sigma x_i F_i}{\sum F_i} \qquad (1)$$

where x_i is the continual indication of the weight of each response (1 to 5), F_i is the frequency of the response.

3.2.2 Standard Deviation

The standard deviation will be calculated using Eq.(2) **(Scheaffer et al.,2010)**.

$$s = \sqrt{\frac{(x_i - \bar{x})^2 F_i}{n-1}} \quad (2)$$

3.2.3 Standard Normal Distribution

The hypothesis of this research takes into consideration the validity of the zero hypothesis (H0), and the alternative hypothesis (H1) is described as follows:
H0: Some factors do not affect the safety performance.
H1: Some factors affect the safety performance.
The normal distribution will be used to test the hypotheses. The value of "z" for all factors will be calculated. The Z value for confidence level 95% ranges between (-1.96 and 1.96), is shown in **Fig. 1**. The Z value will be calculated using Eq.(3)**(Scheaffer et al.,2010)**.

$$z = \frac{\bar{x} - \mu_0}{\frac{\sigma}{\sqrt{n}}} \quad (3)$$

where μ_0 =3, $\bar{x}$ is sample mean, σ is standard deviation, Z is calculated Z, and n is the number of responses.

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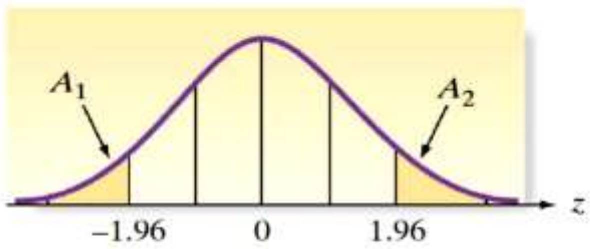

Figure 1. Standard Normal Distribution for 95% Confidence Level.

3.2.4 Reliability Test

The Cronbach's alpha method would assess the internal consistency of the scale's reliability and related items. The reliability levels and Cronbach's alpha coefficient range are given in **Table 2**.

Table 2. Cronbach's Alpha Coefficient Range and Reliability Levels.

Coefficient of Cronbach's Alpha	Reliability Level
1.00	Very high
0.80-0.99	High
0.60-0.79	Moderate
Less than 0.59	Low

4. RESULTS AND DISCUSSION

One hundred sets of questionnaires were delivered to respondents in various construction projects, where 56 questionnaires were disseminated via Google Forms, and 44 questionnaires were distributed manually.

Only 90 questionnaires were answered, representing a 90% response rate. Among 44 responses distributed by hand, 6 responses were recognized invalid because of blank answers. The 84 (84%) collected questionnaires were considered reliable and adequate for this part of the research. **Table 3** compares the distributed, returned, valid, invalid, and unreturned questionnaires.

Table 3. Comparison of the distributed, returned, valid, invalid, and unreturned questionnaires.

Description	Quantity	Percentage %
Distributed questionnaire	100	100
Returned and valid questionnaire	84	84
Questionnaire was returned but invalid	6	6
Unreturned questionnaire	10	10

Table 4 represents respondent demographic information, including qualifications, job titles, and experience years in construction projects. This table illustrates that 42.9% of respondents have a bachelor's degree, 45.2% have a master's degree, and 11.9% have a Ph.D. The respondents' jobs in projects were varied, as shown in **Table 4**.

Table 4. Demographic Details.

Demographic criteria	Frequency	Percentage%
Qualification		
Bachelor's degree	36	42.9
Master's degree	38	45.2
Ph.D.	10	11.9
Job title		
Project manager	17	20.2
Safety manager	10	12
Safety supervisor	16	19
Site engineer	25	29.8
Designer	6	7.1
Academic researchers	10	11.9
Experience years		
Between 1 to 5 years	14	16.7
Between 6 to 10 years	17	20.2
Between 11 to 15 years	30	35.7
Between 16 to 20 years	10	11.9
21 years and more	13	15.5
Total	84	100

The top percentages have been contributed by safety officers, which were 31%, including (safety supervisors at 19% and safety managers at 12%). Site engineers followed by 29.8 %,

project managers by 20.2%, academic researchers by 11.9%, and the lowest percentage was by designers by only 7.1%.
Also, this table illustrates that 35.7% of respondents have more than ten years of working experience in construction projects, followed by 20.2% of respondents with 6 to 10 years of work experience. 15.5% of respondents with more than 21 years of experience and 11.9% with 16 to 20 years of experience. However, only 16.7% of respondents have less than six years of working experience in construction projects. Since many respondents have more than ten years of experience, their opinions in the questionnaire could be concluded to be reliable.
According to **Table 5,** some significant results are identified: Among all the main factors, "Management Practices," with a score of 4.46, was considered the most important safety performance factor. "Safety Commitment," with a score of 4.36, was the second most important factor among the main safety factors. Meanwhile, "Employee Involvement" and "Safety in Contracts" were identified as the third and fourth important safety performance factors, with scores of 4.29 and 4.18, respectively. On the other hand, "SAFETY IN DESIGN" and "SAFETY INCENTIVE," with scores of 3.82 and 3.77, respectively, are considered the least important safety performance factors.
The sub-factors analysis and Cronbach's alpha reliability test for all factors are shown in **Table 6**. Based on the results, among all the sub-factors, "Personal protective equipment," "First aid and medical care," and "Contractor's site safety program" earned the highest importance with scores of 4.27, 4.25, and 4.20, respectively. Furthermore, "sub-contractors site safety program,", "Safety risk identification in the construction drawings," and "Drug and alcohol tests for workers" are considered the least important safety factors, with scores of 3.68, 3.67, and 3.15, respectively.
Finally, according to the statistical analysis results shown in **Table 6**, the factors measured from the rank of 31 to the rank of 35 are factors that do not affect the safety performance of construction projects, where the mean scores of these factors indicate that these factors are unimportant. The Z values for these factors are less than 1.96 for a 95% confidence level.

Table 5. Mean Scores and Ranking of Safety Performance Factors and Sub-factors.

Safety Performance Factors and Sub-factors	Mean score	Rank
1. Management Practices	4.46	1
1.1Personal protective equipment (PPE)	4.27	1
1.2 First aid and medical care	4.25	2
1.3 Contractor's Site Safety Program	4.20	3
1.4 Accident Investigation Program	4.12	4
1.5 Housekeeping program	4.04	5
1.6 Emergency response plan	3.98	6
1.7 Construction equipment management	3.77	7
1.8 Subcontractors site safety program	3.68	8
1.9 Drug and alcohol tests for workers	3.15	9
1.10 Utilizing technology in safety management	2.56	10
2. Safety Commitment	4.36	2
2.1 Management's Safety Commitment	4.06	1
2.2 Owner's Safety Commitment	3.96	2

2.3 Financial resource allocation for safety	3.95	3
2.4 Management and personnel responsibilities definition relating to safety	3.90	4
Safety Performance Factors and Sub-factors	Mean score	Rank
3. Employee Involvement	4.29	3
3.1Set up a safety committee	4.07	1
3.2 Safety Supervisor Appointment	3.88	2
4. Safety in Contracts	4.18	4
4.1 Safety requirements identification in the contract	4.02	1
4.2 Owner approval of the safety plan provided by the contractor	3.87	2
4.3 High level of safety policies	3.87	3
4.4 Offering material safety data sheets	3.85	4
4.5 Safety risk identification in the construction drawings	3.66	5
5. Safety Training	3.95	5
5.1 Safety training course for all workers	3.90	1
5.2 Safety training for supervisors	3.85	2
5.3 Toolbox talks	2.46	3
5.4 Safety training for designers	2.32	4
6. Safety Audits and Inspections	3.92	5
6.1 Regular safety inspections	3.89	1
6.2 Safety Risk Identification	3.80	2
6.3 Contractor Auditing Program	3.74	3
Safety Performance Factors and Sub-factors	Mean score	Rank
7. Contractor Selection	3.90	7
7.1Contractor selection by owner	3.95	1
7.2 Subcontractor selection by the contractor	3.81	2
8. Safety in Design	3.82	8
8.1 Communicating safety requirements to the designer	3.80	1
8.2 Engaging safety professionals to review the design	3.76	2
8.3 Safety commitment among designers	2.45	3
9. Safety Incentive	3.77	9
9.1 Contractor safety rewards and punishment programs	3.74	1
9.2 Sub-contractor safety rewards and punishment programs	2.18	2

Table 6. Ranking, Cranach's Alpha test, mean scores, Standard deviation, and z value of each safety performance sub-factor.

Rank	Safety Performance Factors	Cranach's Alpha	Mean score	Std. Deviation	Z
1	Personal protective equipment (PPE)	0.958	4.27	0.855	13.651
2	First aid and medical care	0.958	4.25	0.890	12.872
3	Contractor's site safety program	0.958	4.20	0.861	12.796
4	Accident Investigation program	0.957	4.12	0.782	13.109
5	Set up a safety committee	0.958	4.07	0.861	11.401
6	Management's safety commitment	0.958	4.06	0.869	11.172
7	Housekeeping program	0.958	4.04	0.975	9.736
8	Safety requirements identification in the contract	0.958	4.02	0.891	10.526
9	Emergency response plan	0.958	3.98	0.957	9.353
10	Owner's safety commitment	0.957	3.96	0.924	9.563
11	Financial resource allocation for safety	0.958	3.95	0.890	9.803
12	Contractor selection by owner	0.96	3.95	0.917	9.518
13	Safety training course for all workers	0.958	3.90	0.801	10.354
14	Management and personnel responsibilities definition relating to safety	0.958	3.90	0.989	8.382
15	Regular safety inspections	0.958	3.89	0.970	8.439
16	Safety supervisor appointment	0.958	3.88	0.974	8.286
17	Owner approval of the safety plan provided by the contractor	0.958	3.87	0.941	8.461
18	High level of safety policies	0.958	3.87	0.967	8.24
19	Offering material safety data sheets	0.958	3.85	0.976	7.941
20	Safety training for supervisors	0.958	3.85	1.024	7.567
21	Subcontractor selection by the contractor	0.959	3.81	0.925	8.025
22	Communicating safety requirements to the designer	0.958	3.80	0.991	7.375
23	Safety risk identification	0.958	3.80	1.062	6.885
24	Construction equipment management	0.958	3.77	0.812	8.736
25	Engaging safety professionals to review the design	0.959	3.76	1.104	6.323
26	Contractor safety rewards and punishment programs	0.959	3.74	0.958	7.058
27	Contractor Auditing Program	0.958	3.74	0.983	6.88
28	Sub-contractors site safety program	0.959	3.68	1.055	5.897
29	Safety risk identification in the construction drawings	0.958	3.67	0.998	6.122
30	Drug and alcohol tests for workers	0.96	3.15	0.719	1.971
31	Utilizing technology in safety management	0.96	2.56	0.896	- 4.503
32	Toolbox talks	0.96	2.46	0.813	- 6.037
33	Safety commitment among designers	0.959	2.45	0.949	- 5.287
34	Safety training for designers	0.96	2.32	0.933	- 6.663
35	Sub-contractor safety rewards and punishment programs	0.96	2.18	0.838	- 8.981

5. CONCLUSIONS

This article aims to identify the significant safety factors that affect the safety performance in Iraqi construction projects. After conducting a critical literature review of the related literature, a list of 35 factors classified into nine categories of main factors was chosen to rank each according to significance.84 questionnaires were analyzed using statistical methods to get the results and achieve the study's objectives. The results indicated that the management practices factor was the most significant among the main safety program factors. The results also suggest that personal protective equipment, first aid and medical care, and the contractor's site safety program are the most important safety sub-factors.
On the other hand, the subcontractor's site safety program, safety risk identification in the construction drawings, and drug and alcohol tests for workers are viewed as having a low impact on safety performance in construction projects and perceived as less important in influencing safety performance in construction projects. The data obtained from this research may be utilized to help choose the best safety and health programs. This data is useful for prioritizing key factors when building a complete safety program and ensuring that construction companies are not wasting money on inadequate safety programs.

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