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Using the Pivot Pair-Wise Relative Criteria Importance Assessment (PIPRECIA) Method to Determine the Relative Weight of the Factors Affecting Construction Site Safety Performance

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ABSTRACT

In the construction industry, safety issues are considered major concerns. Despite recent attempts to improve safety in the construction sector, this sector is considered dangerous and unsafe. Construction safety management in Iraq is plagued by a high incidence of construction accidents, resulting in a higher number of injuries and fatalities. Creating a safety program is one strategy to alleviate this problem by making safety an intrinsic part of construction projects. Defining which factors are the most significant and have the greatest effect on safety performance is crucial to building a complete safety program. It ensures that construction companies are not wasting money on inadequate safety programs. As a result, this article aims to identify the critical safety factors that influence safety performance in Iraqi construction projects and assign a relative weight to them based on their importance. First, relevant literature was reviewed to identify the safety performance factors. Second, the Pivot Pairwise Relative Criteria Importance Assessment (PIPRECIA), a recently proposed technique for calculating criteria weights, was employed to determine the relative weight of factors. In this paper, a list of 21 sub-factors classified into 8 categories of main factors was identified. Finally, the findings of PIPRECIA show that the "Management Practices" factor has the top rank with a weight of 0.4221 among the other main safety factors. The results also showed that among the 21 sub-factors, the three with the highest weights, 0.0686, 0.0665, and 0.0619, belonged to "Personal protective equipment (PPE)", "First aid and medical care" and "Housekeeping program", which were under the "Management Practices" factor. Further, the "Regular safety inspections" and "Contractor safety rewards and punishment programs" sub-factors were identified as the least important sub-factors with weights of 0.0350 and 0.0333, respectively.

1. INTRODUCTION

One of the world's most dangerous industries has traditionally been the construction industry [1]. The rapid development of new technology has resulted in rapid changes to our society and workplaces, as well as a increased accident complexity and causes [2]. Accidents at work result in the loss of lives, money, and equipment and often create work interruptions [3]. The construction industry has one of the poorest safety records compared to other industries, and it must find a new way to enhance its reputation [4]. A high rate of occupational accidents and deaths in the construction sector is a serious worldwide problem [5].

According to the International Labor 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 may be 3–6 times higher [6].

Construction safety management in Iraq is plagued by a high incidence of construction accidents, with 2018 seeing a 38% increase in accidents within the country's construction industry [7]. Atta and Curtis [8] believe that working This could be related to the traditional approach to occupational safety and health management in Iraqi construction projects [9].

Therefore, the aim of this paper is to determine important safety factors affecting safety performance in Iraqi construction projects and assign a relative weight to them based on their importance. The authors also believe that the findings might be applied to evaluate safety performance and choose the most active elements of safety programs, especially in developing countries such as Iraq.

A variety of methods have been proposed so far in the area of multiple-criteria decision making (MCDM) to measure the importance of individual criteria. These are some of the most well-known and popular ones currently available: the DEMATEL method [10], the AHP method [11], the CRITIC method [12], the Stepwise Weight Assessment Ratio Analysis (SWARA) method [13], the Pivot Pair-wise Relative Criteria Importance Assessment (PIPRECIA) Method [14].

The SWARA approach was used to assign relative importance to each criterion in conjunction with other MCDM techniques. From the perspective of the individuals being polled, the SWARA technique is simpler to implement than other approaches designed to calculate the relative importance of various factors [14]. The first step in using the SWARA technique, however, is to choose criteria and rank them in decreasing order of anticipated importance. This indicates that there is a higher threshold for agreement among evaluators when using the SWARA technique, since all participants must agree on the anticipated importance of the criterion. As a result, the SWARA approach is less suitable for tackling specific issues [15].

Therefore, Stanujkic et al. [14] presented the Pivot Pair-wise Relative Criteria Importance Assessment (PIPRECIA) technique, an adaptation of the SWARA approach that does not need the assent of the respondents about the predicted significance of the criteria. The PIPRECIA technique is well-suited to eliciting the respondents' opinions.

Due to this characteristic, the PIPRECIA approach is appropriate for gathering the respondents' views, which is why it was used in this paper.

2. LITERATURE REVIEW

A safety program is described as the management of processes, workers, and equipment to reduce workplace accidents and injuries [16]. Safety programs are necessary to reduce accident and injury rates by providing a safe workplace for workers and establishing a safety culture within the organization [17].

To improve safety performance, a variety of safety programs and practices may be used. There are also other indicators that can be used to choose and create a construction safety program [16].

In all branches of industry, occupational health and safety are key, particularly in the construction industry. Even though the construction industry is always changing due to new techniques, equipment, and machineries, 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 [18].

Construction safety management is essential for improving the construction industry's future [19]. This includes several activities that are taken to develop, monitor, and manage occupational hazards in the industry, as well as mitigate and protect against them. Despite these efforts, the construction industry is nevertheless plagued by high rates of occupational accidents across the world. Therefore, improving safety management requires identifying and grasping the factors that impact construction safety performance [20].

Based on a review of the literature, the authors identified 21 subfactors classified into 8 categories of factors. In Table 1, these factors and their references are summarized. Also, the authors provided a brief explanation of each factor and discussed the importance of each factor in construction site safety and health programs.

2.1 Safety performance factor

2.1.1 Management practices

Management practices are a set of safety factors linked to the responsibilities of the contractor regarding safety.

(1) Personal protective equipment (PPE)

PPE are equipment and garments worn to be used by workers to protect themselves against injury in construction sites. PPE is intended to protect different areas of the body, such as the eyes with glasses or safety goggles, the face with a face shield, the head with a hard hat, the feet with safety shoes and footwear, and so on. Workers might potentially be injured if their personal protective equipment fails or if they neglect to utilize it [21].

When working in groups or in dangerous situations, the goal is to achieve maximum safety. As a result, PPE should be chosen based on the necessity and access to the working circumstances. Head protective hats, one of the oldest and most often used PPE, protect against impact strikes, resist penetration, and absorb the shock of hits. The most dangerous sources of injury are direct hits on the head from things such as debris, falling equipment, and moving mechanical gear [22].

(2) Housekeeping program

Appropriate housekeeping is critical to ensuring the safety and health of construction workers. Housekeeping procedure defined as keeping workplace clean and orderly through proper storage and removing of waste materials used in construction sites. It includes all the materials, equipment, and tools on the construction site. also, keeping the site access clear of any obstructions, using steel plates to cover any excavated area on-site, keeping the work area and all equipment orderly [2].

(3) Emergency response plan

Making an emergency response plan is creating a strategy to follow in the event of acritical situation or accidents, such as a death or an occurrence that resulted in major injuries. Employees must be conversant with emergency action plans prior to a crisis to implement an effective emergency response plan [16]. Rashid et al. [23] considered the absence of emergency response planning on construction sites to be an important area that affected safety performance.

(4) Accident investigation program

It includes documenting and reporting the details of all accidents and near-misses to permit accident data analysis and the identification of errors so that remedial measures may be taken [16]. The method involves analyzing accident data to identify safety program weaknesses. The goal of an investigation is to determine the cause of an accident so that suggestions may be made to avoid similar events in the future and to change any safety management methods that are in place [24]. According to Bello [25], companies that reported and documented accidents and near-miss occurrences had superior safety performance and reduced injury rates. Meanwhile, a review by top management and involvement in investigations into recordable injuries would lower the likelihood of future accidents.

(5) Contractor site safety program

When it comes to dealing with safety issues, proper planning in the early phases by addressing safety issues will result in the development of a safe space with a high morale, fewer disagreements, and good mobility. It will save time, save expenses, and increase quality indirectly [26]. According to Rajendran [27], the following aspects should be included in a contractor site safety plan: emergency response planning, return to work program, safety signage, targeted injury reduction strategy, lockout, and tag out.

(6) Drug and alcohol tests

This safety program element planned to identify and prevent substance abuse [28]. Alcohol abuse is often seen as a major hazard to workers' lives, health, and safety, as well as bystanders. It is generally known that drug usage (alcohol, cigarettes, psychotropic substances) has an impact on the likelihood of an accident in several sectors of the economy, including the construction industry [29]. According to Mushi & Manege [30], construction Workers who abuse alcohol are three times more likely to be involved in occupational related injuries. Furthermore, 35% of emergency department patients from work-related incidents had a history of alcohol abuse or substance usage.

2.1.2 Safety trainning

The purpose of safety training is to deliver the content of a safe working process, such as appropriate machine operation, suitable processes for construction tasks, and how to avoid risks [31]. By creating an awareness of accident hazards, safety education and training would improve safety performance.

To establish a safe working culture, construction safety education and training must be given high attention [22].

All newly recruited workers must attend training classes that include the required skills as well as safety awareness. Any training system must be evaluated to guarantee that the training is adequate and that it may be improved further [32].

Table 1. Main and sub-factors influencing safety performance

Main factors	Code	Sub-factors	Source
Management Practices	SF1	Personal protective equipment (PPE).	[16], [28], [33], [34]
	SF2	Housekeeping program.	
	SF3	First aid and medical care.	
	SF4	Emergency response plan.	
	SF5	Accident investigation program.	
	SF6	Contractor site safety program.	
	SF7	Drug and alcohol tests for workers.	
Safety Training	SF8	Course training on safety for all workers.	[18], [20], [35], [36]
	SF9	Safety training for supervisors.	
Safety Commitment	SF10	Management's safety commitment.	[16], [18], [22], [34], [37]
	SF11	Owner's safety commitment.	
	SF12	Financial resource allocation for safety.	
	SF13	Management and personnel responsibilities definition relating to safety.	
Safety inspections	SF14	Regular safety inspections.	[16], [18], [34], [38]
Safety In Contracts	SF15	Safety requirements identification in the contract.	[16], [39 – 41]
	SF16	Owner approval of the safety plan provided by the contractor.	
	SF17	High level of safety policies.	
Contractor Selection	SF18	Contractor selection by owner.	[34], [39], [42]
Employee Involvement	SF19	Set up a safety committee.	[37], [39], [43]
	SF20	Safety supervisor appointment.	
Safety Incentive	SF21	Contractor safety rewards and punishment programs.	[19], [20], [22], [44]

2.1.3 Safety commitment

Management commitment is the leadership, vision, and resources provided by management to implement an effective safety and health program [45]. Participating in frequent safety meetings, determining clear safety roles among management and employees, sitting on committees, and providing financing for other safety and health program aspects are all examples of management commitment to comply with safety regulations [46].

Management's commitment to safety necessitates considering the safety and health of all workers as a primary aim of the company [47]. Previous research has also shown that owner commitment to safety is required to properly execute all safety strategies. Clients' lack of engagement in contractors' safety activities may have a negative impact on the safety performance of a construction project [48].

2.1.4 Safety inspections

The purpose of a safety inspection and monitoring is to evaluate the physical working conditions of a work site to identify uncontrolled and potentially dangerous exposures to workers. Site safety inspections could be executed by (e.g., safety supervisor, project manager, and safety officer, etc.).

Safety inspections are also a good way to find possible safety issues and correct them to minimize the number of accidents [32].

According to Yap et al. [49], daily safety inspection is required to monitor safety performance and reduce the risk of accidents. Furthermore, if safety inspections are conducted rigorously and on a regular basis, construction site performance may be improved.

2.1.5 Safety in contracts

One of the serious issues in construction safety is the absence of explicit contractual safety responsibility. As a result, it is in everyone's best interest to assign suitable contractual safety duties before the contract is executed. In the construction industry, clear assignment of safety obligations in contracts would improve overall project safety performance and reduce claims, disagreements, and disputes connected to safety injuries [41]. In the contract and documents with the contractor, the owner must state safety and health requirements [50].

2.1.6 Contractor selection

One of the key strategies that project owners may use to enhance project safety performance is to choose contractors based on safety [27]. According to Hansen [51], contractors are a critical component of an organization's safety performance. Hansen stated that prequalification and selecting of contractors were key characteristics of the organization's safety management system. Boadu et al. [52] also suggested that to increase health and safety performance, clients should concentrate on choosing safe contractors.

The many criteria to consider while selecting contractors are summarized in the following [53] : Contractor incident rates (involves OSHA recordable injury rates, lost workday injury, first aid injury rates etc.), observation of workers behavior , regular safety inspection , osha records and fines , performance records of key personnel, key personal performance reputation and records, qualification safety surveys of contractor, perception of workers to safety, litigation related to injuries and site specific safety plan.

2.1.7 Employee involvement

All employees should be involved in implementing safety program responsibilities such as attending safety meetings and toolbox presentations, leading a safety committee, and allowing workers to cease work. As a result, a well-organized safety review method is required to ensure that the project meets its goals [46].

Employee involvement has been largely regarded as the significant element impacting organizational safety among all organizational aspects related to safety. Employee involvement gives practical ways to solve safety issues and demonstrate their own commitment to safety, which may raise workers' incentive to take responsibility for safety and prevent potentially dangerous behaviors and accidents in the workplace [54].

2.1.8 Safety incentive

Safety incentive is one of the proactive techniques utilized by management to motivate employees to work safely. in the other word, a safety incentive program provides workers with rewards for achieving certain goals related to the safety at a workplace. Workers might be rewarded with money or non-financial incentives to participate in safety initiatives [55]. According to Bello [25], construction organizations who implemented a safety reward system had a lower injury rate than those that did not. The company should reward workers who do well in terms of safety.

3. RESEARCH METHODOLOGY

3.1 Data collection

3.1.1 literature review

Based on a critical review of relevant literature related to the factors that affect safety and health performance in worldwide construction projects, the authors identified 21 subfactors classified into 8 categories of factors.

3.1.2 Questionnaire design

After determining factors affecting safety performance, a PIPRECIA questionnaire with pairwise comparisons was developed. The questionnaire was designed to collect views on the relative importance of factors. In the questionnaire, respondents were asked to use the PIPRECIA method's relative importance scale to determine the relative importance of all the identified subfactors. Appendix A shows the designed questionnaire.

When using a pairwise comparison between factors, the question form is as follows: "What is the importance of the second factor compared with the first factor." The respondents will choose one of the following responses to indicate the relative significance: 1=two factors have equal importance, <1=the second factor has less importance than the first, >1=the second factor has more importance than the first.

3.2 Sample size

Probability sampling and non-probability sampling are the two types of sampling. A key distinction between probability and non-probability sampling is that the latter does not rely on a random selection process. Quantitative studies often use a random sampling strategy, whereas qualitative studies frequently use a non-random strategy [56]. The choice between probability and non-probability sampling methods depends on the study questions and goals, as well as practical issues like time and resource constraints [57]. Some type of random sample design may be used if research issues need representativeness [58]. On the other hand, non-random sampling is preferable if the research objectives require comparisons between variables [57].

In this study, probability sampling was not applied because of two reasons. First, the respondents include construction safety officers and academic experts, which are a small part of the general population. Second, using probability sampling brings up the risk of excluding important respondents during the process. In non-probability approach the samples would be chosen from a larger population without random selection. The non-probability sampling approaches include purposive, convenience, quota, snowball sampling and self-selection [57].

Moreover, the major purpose of the research is to determine important safety factors affecting safety performance in Iraqi construction projects and assign a relative weight to them based on their importance, which requires investigation of relationships between different types of theoretically important variables. Therefore, it was essential to select a sample, that contained the characteristics of theoretically relevant variables. The use of a Non-random purposeful sampling method allows respondents with expertise in the safety and health performance of construction projects in Iraq to be included in samples.

Table 2. Experts' demographic profile

No	Position	Education level	Experince years	Sector
1	Project manager	MSc	18	Private sector
2	Director	MSc	25	Private sector
3	Site engineer	BSc	15	Government
4	Director	PhD	30	Private sector
5	Consultant	PhD	20	Independent Consultant
6	Researcher	MSc	16	Government
7	Project manager	PhD	21	Private sector
8	Senior manager	BSc	26	Government

In this study, non-random purposive sampling was used. Purposive sampling involves the researcher making a decision about what kind of sample units to include in the study and the knowledge of respondents is one of the key issues in the process [56]. As Tansey [59] believed, only specific group of respondents are qualified and needed to be involved in the research process.

Non-random, purposeful sampling was used in this study. In non-random sampling processes, Experts' quality is more significant than their number [16]. In the PIPRECIA method, the number of participants in the research study's sample size can be as small as a select group of specialists [14].

In line with previous study by [16, 58], 10 experts were contacted, and 8 of them consented to take part. Table 2 lists the number of experts who contributed to this study.

3.3 Data analysis techniques

3.3.1 PIPRECIA method

According to Stanujkic et al. [14], the methodology used by the PIPRECIA technique to determine criterion weights may be appropriately summed up as follows:

Step 1. Determine the important evaluation criteria and put them in order from most important to least important. Arranging the criteria, however, is optional and may be ignored.

Step 2. Start with the second criterion and set the relative importance *Sj* as follows:

$$Sj = \begin{cases} > 1 \; if \; Cj > Cj - 1 \\ = 1 \; if \; Cj = Cj - 1 \\ < 1 \; if \; Cj < Cj - 1 \end{cases} \tag{1}$$

where, Cj represents the importance of criterion j and Cj-1 represents the importance of the previous j-1 criterion.

Step 3. The *Kj* coefficient can be calculated based on:

$$Kj = \begin{cases} 1 \; if \; j = 1 \\ 2 - sj \; if \; j > 1 \end{cases} \tag{2}$$

Step 4. Calculate the recalculated weight *qj* as follows:

$$qj = \begin{cases} 1 \; if \; j = 1 \\ qj = \frac{qj-1}{kj} \; if \; j > 1 \end{cases} \tag{3}$$

Step 5. Calculate the relative weight w_j of the criteria as follows:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_j} \tag{4}$$

Step 6. Calculate the group weights of the criteria as follows:

$$w_j^* = \left(\prod_{k=1}^{k} w_j^r\right)^{1/k} \tag{5}$$

$$w_{j_F} = \frac{w_j^*}{\sum_{j=1}^{n} w_j^*} \tag{6}$$

where, w_j^* represents the geometric mean of the weights of criterion *j* obtained by surveying respondents and *k* represents the respondents' number.

4. RESULTS AND DISCUSSION

The questionnaire survey was distributed by hand to eight experts, the eight experts made their pair-wise comparisons between the sub-factors. Table 3 presents respondents' attitudes.

After determining the (*Sj*) value for all factors, the next step is to use Eq. (2), Eq. (3), and Eq. (4) to calculate the relative weight of the safety performance factors. The calculations and weight obtained from the first responder are shown in Table 4.

The same steps that were followed to obtain the weight of factors from the first respondent, as shown in Table 4, were used to obtain the weight of factors for all respondents. Table 5 shows the weights collected from all respondents and illustrates the group's weights computed using Eq. (5) and Eq. (6).

Table 6 and Figure 1 illustrate the final weights of each safety performance factor obtained by using the PIPRECIA technique.

The calculation of the relative weight of the safety performance factors and the measurement of each factor's contribution to the influences on safety performance are essential part of this research.

Referring to Table 6, among the 21 sub-factors, the six with the highest weights of 0.0686, 0.0665, 0.0619, 0.0603, 0.0599 and 0.0561 belonged to "Personal protective equipment (PPE)", "First aid and medical care", "Housekeeping program", "Contractor site safety program", "Emergency response plan" and " Accident investigation program ".

According to the weights calculated above, it can be seen that the first six factors with the highest weight belong to the management practices factor.

The management practices factor includes many safety subfactors linked to the responsibilities of the contractor regarding safety at the construction site. Evidently, experts place the highest significance on the factor of management practices. This indicates that the primary responsibility for safety lies with the contractor.

The majority of safety incidents happen during construction. As a result, regularly assessing contractor safety compliance is essential to reducing safety risks.

The current study's findings agree with previous research [18, 60] indicating personal protective equipment is the most significant factor impacting construction site safety performance. When working in groups or in dangerous situations, the goal is to achieve maximum safety. As a result, PPE should be chosen based on the necessity and access to the working circumstances.

On the other hand, the "Regular safety inspections" and "Contractor safety rewards and punishment programs" sub factors were identified as the least important sub factors with weights of 0.0350 and 0.0333, respectively.

"Regular safety inspections" and "Contractor safety rewards and punishment programs" are ranked at the lowest level of importance. These two factors appear to have received relatively low weights from the experts.

According to Hallowell [61], site safety inspections are executed by the safety committee. It is possible that experts have considered safety inspections one of the safety committee's responsibilities. As a result, they assigned relatively low weight to the safety inspection factor.

Table 3. Respondents' attitudes about the significance of the factors

Expert	SF2 ↔ SF1	SF3 ↔SF2	SF4 ↔ SF3	SF5 ↔ SF4	SF6 ↔ SF5	SF7 ↔ SF6	SF8 ↔ SF7	SF9 ↔ SF8	SF10 ↔ SF9	SF11 ↔ SF10	SF12 ↔ SF11	SF13 ↔ SF12	SF14 ↔ SF13	SF15 ↔ SF14	SF16 ↔ SF15	SF17 ↔ SF16	SF18 ↔ SF17	SF19 ↔ SF18	SF20 ↔ SF19	SF21 ↔ SF20
1	0.9	1	1	0.8	1	0.7	1.2	1	0.9	0.8	0.7	1.2	1	1.2	1	1.2	0.7	1.2	0.9	1
2	0.9	1.2	0.9	1.2	1.2	0.8	1	0.9	0.8	1	0.9	1	1.2	1.2	0.8	0.9	0.9	1.2	0.8	0.9
3	1	1	0.8	0.9	1.2	0.7	1.2	1.2	0.8	0.9	0.8	0.7	1	1	0.9	1	1	1.2	0.8	1.2
4	0.8	0.9	0.9	1	1	0.8	1	1	0.9	1.2	1	0.9	0.9	1	0.8	1	0.8	1	1	0.8
5	0.9	1.2	0.9	0.9	0.9	0.8	1.2	1	1	0.8	0.9	0.9	1	0.9	0.9	1.2	0.7	1	0.9	0.8
6	1	1.2	0.8	0.8	1	0.7	1	0.9	0.7	0.7	0.8	0.8	1.2	1	1	1.2	0.9	1.2	1	0.8
7	0.7	1	1	0.9	1	0.9	1.2	1	0.8	0.9	0.8	1	1	1.2	0.7	1	0.9	1.2	0.8	0.9
8	0.9	1	0.8	0.9	1.2	0.7	1.2	0.8	0.9	0.9	0.8	0.9	1.2	1	0.9	1.2	0.8	1	0.7	1

Table 4. The weight of factors obtained from the first respondent

Factor	s_j	k_j	q_j	w_j
SF1	-	1	1	0.06657
SF2	0.9	1.1	0.909	0.06052
SF3	1	1	0.909	0.06052
SF4	1	1	0.909	0.06052
SF5	0.8	1.2	0.758	0.05043
SF6	1	1	0.758	0.05043
SF7	0.7	1.3	0.583	0.03879
SF8	1.2	0.8	0.728	0.04849
SF9	1	1	0.728	0.04849
SF10	0.9	1.1	0.662	0.04408
SF11	0.8	1.2	0.552	0.03674
SF12	0.7	1.3	0.424	0.02826
SF13	1.2	0.8	0.531	0.03532
SF14	1	1	0.531	0.03532
SF15	1.2	0.8	0.663	0.04415
SF16	1	1	0.663	0.04415
SF17	1.2	0.8	0.829	0.05519
SF18	0.7	1.3	0.638	0.04246
SF19	1.2	0.8	0.797	0.05307
SF20	0.9	1.1	0.725	0.04825
SF21	1	1	0.725	0.04825
		SUM	15.022	1.00000

Table 5. The group weights of the factors

Factors	**Expert 1 W j**	**Expert 2 W j**	**Expert 3 W j**	**Expert 4 W j**	**Expert 5 W j**	**Expert 6 W j**	**Expert 7 W j**	**Expert 8 W j**	**w*j**	**W j f**
Sf1	0.0666	0.0418	0.0632	0.0819	0.0651	0.0814	0.0760	0.0746	0.0675	0.0686
Sf2	0.0605	0.0380	0.0632	0.0683	0.0591	0.0814	0.0585	0.0678	0.0609	0.0619
Sf3	0.0605	0.0475	0.0632	0.0621	0.0739	0.1018	0.0585	0.0678	0.0655	0.0665
Sf4	0.0605	0.0432	0.0527	0.0564	0.0672	0.0848	0.0585	0.0565	0.0590	0.0599
Sf5	0.0504	0.0540	0.0479	0.0564	0.0611	0.0707	0.0532	0.0514	0.0552	0.0561
Sf6	0.0504	0.0675	0.0599	0.0564	0.0555	0.0707	0.0532	0.0642	0.0594	0.0603
Sf7	0.0388	0.0562	0.0461	0.0470	0.0463	0.0544	0.0483	0.0494	0.0480	0.0488
Sf8	0.0485	0.0562	0.0576	0.0470	0.0579	0.0544	0.0604	0.0618	0.0552	0.0561
Sf9	0.0485	0.0511	0.0720	0.0470	0.0579	0.0494	0.0604	0.0515	0.0542	0.0551
Sf10	0.0441	0.0426	0.0600	0.0427	0.0579	0.0380	0.0504	0.0468	0.0473	0.0480
Sf11	0.0367	0.0426	0.0545	0.0534	0.0482	0.0293	0.0458	0.0425	0.0434	0.0441
Sf12	0.0283	0.0387	0.0454	0.0534	0.0438	0.0244	0.0381	0.0354	0.0374	0.0380
Sf13	0.0353	0.0387	0.0349	0.0486	0.0398	0.0203	0.0381	0.0322	0.0351	0.0357
Sf14	0.0353	0.0484	0.0349	0.0441	0.0398	0.0254	0.0381	0.0403	0.0377	0.0383
Sf15	0.0442	0.0605	0.0349	0.0441	0.0362	0.0254	0.0477	0.0403	0.0405	0.0412
Sf16	0.0442	0.0504	0.0318	0.0368	0.0329	0.0254	0.0367	0.0366	0.0362	0.0367
Sf17	0.0552	0.0458	0.0318	0.0368	0.0412	0.0317	0.0367	0.0458	0.0399	0.0406
Sf18	0.0425	0.0417	0.0318	0.0307	0.0317	0.0289	0.0333	0.0381	0.0345	0.0350
Sf19	0.0531	0.0521	0.0397	0.0307	0.0317	0.0361	0.0417	0.0381	0.0397	0.0403
Sf20	0.0482	0.0434	0.0331	0.0307	0.0288	0.0361	0.0347	0.0293	0.0350	0.0355
Sf21	0.0482	0.0395	0.0414	0.0255	0.0240	0.0301	0.0316	0.0293	0.0328	0.0333

Table 6. Final weights of safety performance factors

Rank	Safety Performance Factors	Final weight
1	Personal protective equipment (PPE).	0.0686
2	First aid and medical care.	0.0665
3	Housekeeping program.	0.0619
4	Contractor site safety program.	0.0603
5	Emergency response plan.	0.0599
6	Accident investigation program.	0.0561
7	Course training on safety for all workers.	0.0561
8	Safety training for supervisors.	0.0551
9	Drug and alcohol tests for workers.	0.0488
10	Management's safety commitment.	0.0480
11	Owner's safety commitment.	0.0441
12	Safety requirements identification in the contract.	0.0412
13	High level of safety policies.	0.0406
14	Set up a safety committee.	0.0403
15	Contractor selection by owner	0.0383
16	Financial resource allocation for safety.	0.0380
17	Owner approval of the safety plan provided by the contractor.	0.0367
18	Management and personnel responsibilities definition relating to safety.	0.0357
19	Safety supervisor appointment.	0.0355
20	Regular safety inspections.	0.0350
21	Contractor safety rewards and punishment programs.	0.0333

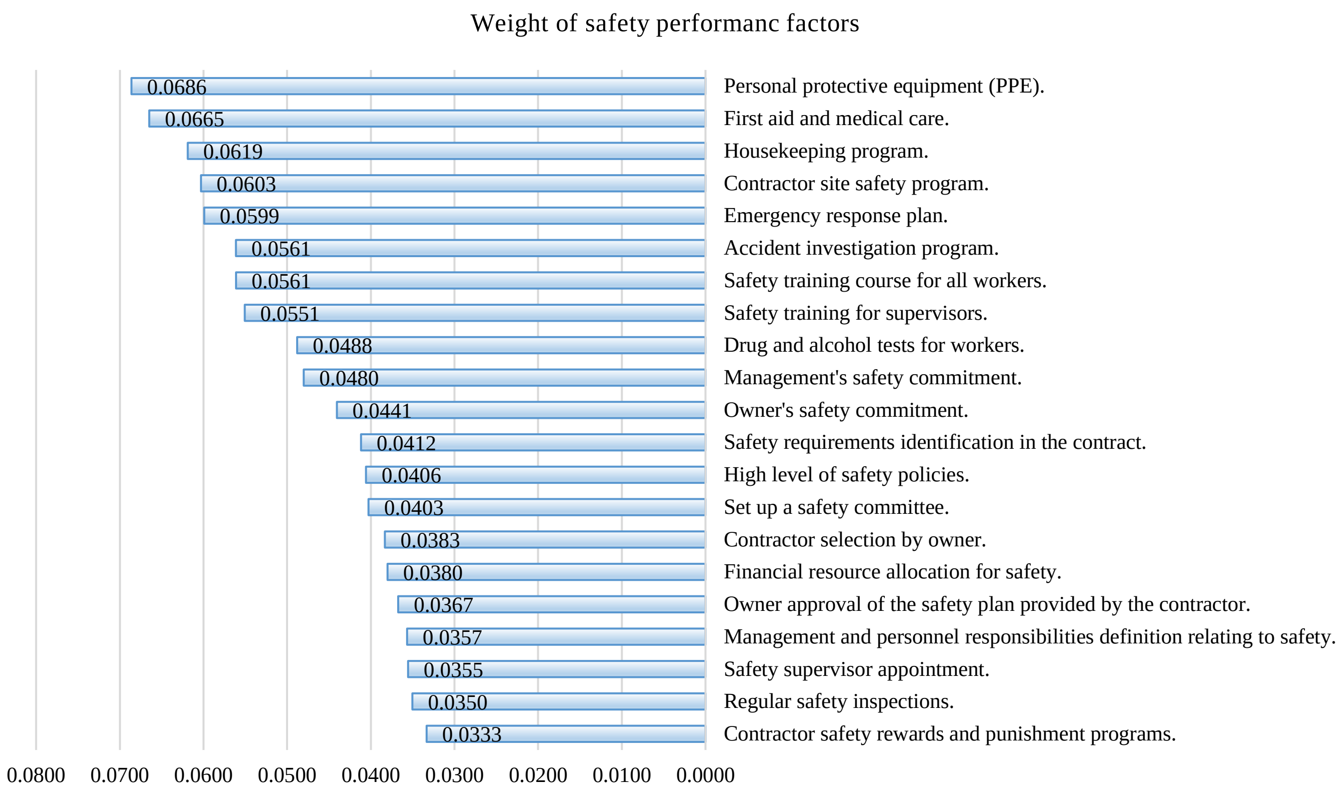

Figure 1. Ranking and weights of safety performance Factors

Meanwhile, it was found that the experts did not give attention to the incentive program, which was found to be the least influential factor on safety performance.

Incentives can be counterproductive when applied to safety programs. This is due to the fact that certain workers may be tempted to hide injuries and illnesses and not report them to the management in order to obtain rewards [44].

Further, according to OSHA [62], safety incentive programs do not influence workers' behavior regarding safety but rather result in chang the rate of accidents reporting.

While the authors believe that safety incentives have the potential to improve safety performance, they stress the need for tailoring incentive programs to the needs of each worker in order to reduce the likelihood that workers may feel pressured to keep health issues hidden.

Together, the top ten sub-factors constitute approximately 58.13% of the total weight of all sub-factors . Among the top ten sub-factors, seven sub-factors were under the "Management Practices" factor, two sub-factors were under the "Safety Training" factor, and one sub-factor was under the "Safety Commitment" factor. These factors must be given the most attention because they have the most important elements to address safety in construction projects.

5. CONCLUSIONS

This study presented the important safety factors that have an impact on the safety performance of construction projects in Iraq. The Pivot Pairwise Relative Criteria Importance Assessment (PIPRECIA), a recently proposed technique for calculating criteria weights, was employed to determine the relative weight of factors. The PIPRECIA tool has a substantial influence on decision-making and calculating the final weight of factors. This technique distinguishes itself in that it does not need to arrange the criteria according to their expected importance. In other words, the experts are not forced to follow a specific order of the factors. Each expert assigns importance according to his opinion. The authors also confirm the applicability of this technique with pairwise comparison questionnaires.

The other important finding is that the data obtained from this research may be utilized for prioritizing key factors when building a complete safety program and ensuring that construction companies are not wasting money on inadequate safety programs. Further, the authors also believe that the obtained weights of the factors can be used to evaluate safety performance at the construction site and monitor the contractor's compliance with the safety issues.

Finaly , It's worth stressing that the surveys were done with Iraqi industry practitioners and within the framework of this study. What this implies is that local environment and culture have a role in determining the relative importance of impact strengths for components in safety programs.

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