



## Strategies for Improving Construction Safety Performance in Developing Context

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### Abstract

Inexperience and lack of awareness of workplace appropriate actions are the common reasons behind accidents and injuries. Researchers and industry practitioners in developed countries identified more than 12 strategies that might lead to preventing worksite injuries. However, these strategies are specific to the developed context. Developing countries still fail to identify safety strategies that might align with their safety policies and procedures. This paper aims to take the first step towards identifying the best safety strategies in the developing context. Thus, the main research question is how can companies start to implement safety strategies with consideration of their context? This study applied a mixed method to meet the objectives of the study. The Delphi method was used to obtain the needed data. The descriptive analysis shows that four important strategies are identified out of the 12 strategies: Upper Management Support, Safety and Health Committees, Record Keeping and Accident Analysis, and Job Hazard Analyses. The findings of this paper can be used by managers to make defensible decisions to start implementing safety strategies in their organizations. Also, they will illuminate the developing countries' safety culture perspective and the implementation processes.

**Keywords:** Construction safety; Developing context; Libya; Delphi method

### 1 Introduction

In the field of construction, workers are exposed to accidents and get injured. Such a problem can be avoided by implementing safety management through identified strategies. As an example, construction industry in the US employs approximately 25% of the industrial workforce but has generally accounted for the highest rate of all industrial workers in the fatalities rate (NIOSH, 2018). This is twice in cost compared to all industries (Waehrer et al., 2007). Due to the lack of contribution from previous studies in the field of safety in construction, this study aims to contribute to safety in the construction industry in a developing context specifically. This research introduced the topic to Libyan practitioners as one of the developing countries to open the door for newly filed of research to be investigated. Researchers and industry practitioners in developed countries identified more than 12 strategies that might lead to preventing worksite injuries. This study aims to explore the possibility of implementing these strategies and techniques in the work zone with local practitioners. The main research question for this research is: *“What are the important safety management strategies that*

construction companies should start implementing with consideration to their local context?”

## 2 Literature Review

This section focuses on reviewing the accidents in the construction industry historically; then the identified safety strategies by the developed countries’ experts were presented.

### 2.1 Accidents in Construction Industry

It is appropriate to consider construction work as inherently dangerous if no proactive steps are taken to improve the work conditions and to ensure that the work is undertaken in a safe manner. Looking back at history helps us to realize that the incidence of injuries and fatalities has decreased by more than 60% in the past three decades (OSHA, 2001). Over the years, since 1997, the Occupational Safety and Health Administration (OSHA) has changed rules and obligations to support workers’ safety (Arbury et al., 2022). The incidence recordable rates have dropped as shown in Figure 1. Other sources such as (US Bureau of Labour Statistics, 2017) confirmed those results. Some researchers such as Hallowell and Gambatese (2009) believe that these improvements are the result of the increased adoption of highly effective safety strategies.

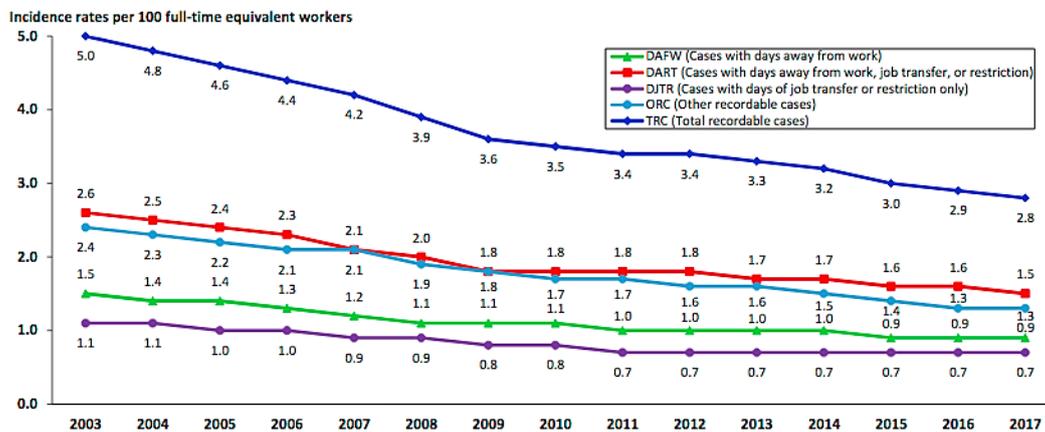


Fig. 1: Rate of Total Recordable Injuries and Illnesses (U.S. Bureau of Labor Statistics, 2018)

Developing countries still fail to identify safety strategies that might align with their safety policies and procedures. In general, accident prevention and its cost are accepted as the responsibility of management. However, not all construction firms commit the same amount of effort or funds to accident prevention. The differences may stem partially from differences in the perception of the degree of influence that management can have on reducing worker injuries (Beus et al., 2015). They may also be consequences of different perceptions of the actual costs related to worker injuries. If the true costs of injuries were well defined, management would be in a better position to make informed decisions concerning safety, rather than addressing safety solely from an altruistic point of view. Companies spent, on average, for managing safety and minimizing accident rates from less than 1 % to 10% of project costs (Dorji & Hadikusumo, 2006).

### 2.2 Identified Safety Strategies in Construction Industry

Based on the conducted studies about construction safety in developed countries, there were 12 highly effective administrative safety innovations identified (Esmaili and Hallowell 2012). In this study, we will depend on these findings to introduce safety strategies to local practitioners as shown in Table 1:

**Table 1: The Proposed Safety Strategies and Techniques**

| No. | Strategy name   | Description  |
|-----|---|--|
| 1   | Upper management support                              | In most companies, it is important to ensure the support of upper management to successfully implement any strategic changes. In this strategy, the employer must warn all the employees/workers before starting work about various risks that they may face at the worksite. They need to know the ways of how to protect themselves based on the provided training. All the needed instructions should be in a noticeable and visible place (Hallowell & Gambatese, 2009).   |
| 2   | Job hazard analyses                                   | Injuries usually occur as a result of working in unsafe physical environments or unsafe practices or both. Knowing and recognizing an unsafe physical condition could directly reduce the probability of injury (Wang et al., 2021). Nevertheless, full dependence could never be placed on a checklist that is used for all kinds and sizes of projects. Therefore, training workers to help them distinguish or identify unsafe physical conditions and follow appropriate and safe work techniques helps to achieve good safety performance.  |
| 3   | Safety and health orientation; training               | According to Kinn et al. (2000), training should be an essential element/factor of every safety program; therefore, it is important that the areas in which training is necessary are classified. All employees need to be trained in hazard communication to make every worker completely knowledgeable about all substances that are expected to be on site. Even the most skillful workers and experienced foremen should become familiar with what is called the job-site plan, the project management personnel, company strategies and rules, and a range of other topics that may be related to an unknown project. |
| 4   | Frequent worksite inspections                         | This strategy is important to identify all circumstances that can efficiently and successfully be corrected. The inspection tour should cover the whole construction work, with specific consideration given to subcontractors' work. This strategy will deliver the same message to all of the workers and subcontractors regarding the importance of the safety (Muto et al., 1997).   |
| 5   | Emergency response planning                           | There should be plans for dealing with and managing the emergency situations such as floods, fires, power outages, windstorms, etc. This could be done by recording and reporting all injuries and illnesses and related investigations. It is widely known that the requirements of the safety program may differ because it depends on the nature of the project (Brown & Dunn, 2007).   |
| 6   | Record keeping and accident analysis                  | This strategy involves documenting and reporting the specifics of all accident information such as time, location, worksite condition, and cause. The analysis should point out the weakness in the company's safety program or the poor implementation of a program element (Ahmed et al., 2019).   |
| 7   | Project-specific training and pre-job safety meetings | Hinze (1997) states that safety meetings include a discussion between a supervisor and all workers on a construction site. These safety meetings might be conducted formally and informally. In addition, safety sessions may be carried out for many levels of supervision (Arquillos et al., 2015).  |
| 8   | Safety and health committees                          | The objective of this strategy is to have a different angle to support the management in their effort to recognize safety improvement. The safety committee is established including some workers. Thus, the members of the committee bring different viewpoints to the group (Milgate et al., 2002).  |
| 9   | Substance abuse programs                              | Requirements that might be carried out by the owner contain the testing (planned and unplanned) of every worker. The goal of this strategy is to demonstrate that when an employee fails a test then it is seen to be common for the company to mandate rehabilitation or help (Hersch et al., 2002).  |
| 10  | Safety manager on-site                                | A knowledgeable person at the job site, chosen by the contractor is usually designed to serve the safety representative, who will be responsible for implementing the safety program. The safety manager or the representative should have adequate authority to improve the work performance, and conditions to minimize hazards and/or dangers. The safety manager or representative must be qualified, and knowledgeable to recognize and identify safety and health hazards (Levitt & Samelson, 1993).   |

|    |  |  |
|----|--|--|
| 11 | Subcontractor selection and management | This involves covering all aspects of on-site construction, operations, and activities related to a particular contract. Many owners now ask contractors to submit what is called project-specific safety programs including subcontractors' selection. It is the commonly required approval before starting construction. Thus, the owner will not accept to process/progress payments if the project safety is not approved (Aksorn & Hadikusumo, 2008). |
| 12 | Employee involvement and evaluation    | It is essential to create a means of evaluating safety performance. That will make it possible to evaluate, assess and even measure the impact of a specific change that the company may aim to achieve. This is an indication that for evaluating and assessing safety performance and employee involvement, there should be what is called a reliable measure (Williams, 2008).  |

### 3 Methodology

This study applied a mixed method to meet the objectives of the study. The Delphi method was used to obtain the needed data.

#### 3.1 Research Setting

The current study presents the research that was conducted in Libya's Misurata city. Both public and private companies and organizations were involved as follows: The Company of Free Zone Misurata; Libyan Iron and Steel Company-the construction department; The Company of Highways and Bridges; The Organization of Development of Administrative Buildings; The General Construction Company; The Office of Maintenance of Misurata International Airport.

#### 3.2 Questionnaire Design

The questionnaire was the main source for collecting research data. To ensure the understanding of the questionnaire's questions and to have reliable answers and feedback, the original questionnaire was written in Arabic. It consisted of three main parts. In the first one, the participants were asked 12 descriptive questions related to personal experience in construction. Also, the previous involvement of the participants in accidents related to construction work. The second part focused on exploring the proposed safety strategies in participants' agencies and organizations. This was assessed using five Likert-scaled ratings from "not applied," to "completely applied." Before asking the participants for their assessments, short descriptive of the proposed safety strategies were presented to them to ensure all have the same understanding of the strategies, thus reliable inputs were obtained. The third part was designed to gain qualitative data about the participants' recommendations about the proposed strategies. The question was-"Which of the strategies does he/she recommend to a company aiming to enhance its safety management performance? After finalizing the questionnaire design, the researchers piloted the questionnaire with professors, and students to ensure the clarity of the questions from the participants' perspectives. Moreover, according to the busy schedule of the potential participants, the length of the questionnaire was checked to ensure its reasonability. The important feedback of this step was the suggestion to add definitions to the proposed strategies which were added in the final design of the questionnaire.

#### 3.3 Data Collection

The questionnaires were distributed to all the targeted companies and organizations following snowballing techniques, which are recommended to be used if there is no database for the potential participants' information such as names, contact numbers, and emails. According to Oppenheim (2001), the researchers could ask a few appropriate individuals to distribute the questionnaire to who might also fit within the targeted sampling in terms of field of experience and topic of the study. The

data collection process lasted for about a month from December 12<sup>th</sup>, 2017 to January 10<sup>th</sup>, 2018. A total of forty-four questionnaires were distributed; however, the response rate was about 84% (i.e. thirty-seven were received). All the participants volunteered to participate in the study and no constraint was applied. In addition, they were informed about their anonymity and were given the right to withdraw from the process at any time.

### 3.4 Analysis Techniques

The researchers conducted a descriptive analysis based on the collected data to present the participants' historical experience in safety-related work. Also, the individual's feedback about which of the proposed safety strategies was implemented in his/her company. The second step of analysis includes using Analytical Hierarchy Process (AHP) technique to obtain the collective ranking of the strategies' importance. The data was collected in three rounds using the Delphi method through emails. Six participants were involved in the whole process of AHP which according to Krueger and Casey (2009) is enough for studies, and aims to reach a consensus among practitioners. The independent participants who were selected according to predefined guidelines from the 37 participants in the first step, were asked to participate in two or more rounds of structured surveys (Hallowell & Gambatese, 2010). Adapting Wind & Saaty (1980) scale, the authors of the current study used the scales, definitions, and explanations as shown in Table 2. A pairwise comparison was carried out between the most important safety strategies. The needed calculations to check the validity of the inputs were conducted and confirmed.

**Table 2:** Rating Scale Used in AHP (Saaty & Vargas, 1991)

| Intensity of importance | Definition                | Explanation   |
|-------------------------|---------------------------|---|
| 1                       | Equal importance          | Two strategies contribute equally to the objective.   |
| 3                       | Somewhat more important   | Experience and judgment slightly favor one over the other.  |
| 5                       | Much more important       | Experience and judgment strongly favor one over the other.  |
| 7                       | Very much more important  | Experience and judgment very strongly favor one over the other. Its importance is demonstrated in practice. |
| 9                       | Absolutely more important | The evidence favoring one over the other is of the highest possible validity.                               |

## 4 Results and Discussion

This section will include the results from the questionnaire under two categories: (1) Descriptive Result; and (2) Analytical Hierarchy Process (AHP) outcomes Descriptive Analysis. The range of current jobs includes general managers, project managers, managers of departments, and workers' supervisors. The participants' roles allowed most of them to witness construction accidents and injuries. The types of injuries and the associated treatments are shown in Table 3.

**Table 3:** Participants' Construction Safety Experience

|                                  |            |       |
|----------------------------------|------------|-------|
| Involvement in field accidents   | Yes        | 27    |
|                                  | No         | 10    |
| Types of injuries and treatments | Fatality   | 11.0% |
|                                  | Disability | 7.5%  |
|                                  | Hospital   | 48.0% |
|                                  | On-site    | 33.5% |

Those participants were asked in the questionnaire about the applied safety strategies in their current companies and/or organizations. The five Likert-Scale ranged from “not applied,” “weakly applied,” “acceptable application,” “well applied,” and “complete application.” Most of the participants indicated that at best the application of the strategies was between the “not applied” and the “weakly applied” categories. Then, the participants suggested the best safety strategies for their companies. Based on the questionnaire design, the participants were allowed to suggest up to two strategies (Table 4). The selected six strategies were selected for the next step of analysis using AHP for comparison and ranking.

**Table 4:** The Suggested Strategies Based on Participants’ Opinions

| #     | Proposed Safety Strategies                    | Suggestion 1 | Suggestion 2 |
|-------|---|--------------|--------------|
| 1     | Upper management support                      | 22           | 11           |
| 2     | Job hazard analyses                           | 2            | 8            |
| 3     | Safety and health orientation and training    | 6            | 7            |
| 4     | Frequent worksite inspections                 | 0            | 0            |
| 5     | Emergency response planning                   | 0            | 0            |
| 6     | Record keeping and accident analysis          | 2            | 3            |
| 7     | Project-specific training and safety meetings | 5            | 2            |
| 8     | Safety and health committees                  | 0            | 6            |
| 9     | Substance abuse programs                      | 0            | 0            |
| 10    | Safety manager on-site                        | 0            | 0            |
| 11    | Subcontractor selection and management        | 0            | 0            |
| 12    | Employee involvement and evaluation           | 0            | 0            |
| Total |   | 37           | 37           |

#### 4.1 Analytical Hierarchy Process (AHP) technique

In the questionnaire, the authors asked the participants to provide their contact information if they agree to be involved in the second phase of the study. Six participants agreed and were invited to the AHP technique. To obtain the pairwise comparison between the six suggested strategies, the authors applied Delphi methods targeting two rounds to reach a consensus among the participants. The authors sent the six participants a matrix that includes the six strategies asking for their pairwise comparison using the scale in Table 1. In the first round, no consensus was achieved among the participants. Therefore, the authors decided to go for another round. The second round started by redistributing the matrix to each one of the participants. In the matrix, the previous participants’ inputs and the mode of the group assessment were provided. The participants were asked to review their assessments, they can keep or change them if needed, and provide the final decision. Table 5 shows the mode pairwise assessment for the participants after the second round.

**Table 5:** The Mode Assessment of the Participants

|                          | Upper management support | Job hazard analyses | Safety and health orientation and training | Record keeping and accident analysis | Project-specific training and safety meetings | Safety and health committees |
|--------------------------|--------------------------|---------------------|--|--------------------------------------|---|------------------------------|
| Upper management support | 1                        | 1                   | 5  | 5                                    | 3   | 1/3                          |

|   |     |     |     |     |     |     |
|---|-----|-----|-----|-----|-----|-----|
| Job hazard analyses                           | 1   | 1   | 5   | 1/3 | 3   | 1/5 |
| Safety and health orientation and training    | 1/5 | 1/5 | 1   | 7   | 1   | 1/5 |
| Record keeping and accident analysis          | 1/5 | 3   | 1/7 | 1   | 7   | 5   |
| Project-specific training and safety meetings | 1/3 | 1/3 | 1   | 1/7 | 1   | 3   |
| Safety and health committees                  | 3   | 5   | 5   | 1/5 | 1/3 | 1   |

To ensure that the obtained judgments (results) are not based on random inputs, the Consistency Ratio (CR) was calculated to measure how consistent the judgments have been relative to large samples of purely random judgments. According to Wind & Saaty (1980), if the CR is more than or equal to 0.9 then the judgments were random and the AHP assessments should be re-applied. Based on Table 5, the CR was found to be 0.86. Even though the CR value was close to 0.9, the authors accepted it and calculated the weights of each strategy. Based on these weights, the rank of the safety strategies is as follows: Upper Management Support (0.266); Safety and Health Committees (0.203); Record Keeping and Accident Analysis (0.187); Job Hazard Analyses (0.155); Safety and Health Orientation and Training (0.096); Project-Specific Training and Safety Meetings (0.093).

## 5 Discussion and Conclusion

This study investigated the safety strategies and their application in the construction field with consideration to the developing context. Questionnaires were distributed among practitioners in Libya as a case study. Their characteristics show that their experiences were relative to the research. The AHP technique facilitated determining the rank among the safety strategies. It is rare in developing countries to have a high number of knowledgeable practitioners. The results indicated that upper management support ranked as highly safety strategy. Recent studies showed that the support and involvement of upper management in all safety aspects stood as a leading indicator for preventing injuries in worksites in the developed context (Alruqi & Hallowell, 2019). The findings of this paper can be used by managers to make defensible decisions to start implementing safety strategies in their organizations. Also, they will illuminate the developing countries' safety culture perspective and the implementation processes. Based on the findings future research paths were opened such as investigating the repeatability of the finding in a wide range of developing countries focusing on MENA and Gulf regions.

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