A review on safety knowledge and skills for reducing human error and accidents in construction

Misbahul Fajar Sidiq[1*] and *Mohammad Arif* Rohman[1]

[1]Department of Civil Engineering, Institut Teknologi Sepuluh Nopember, Sukolilo Campus 60111, Surabaya, Indonesia.

Abstract. Human error remains a significant contributor to construction accidents, highlighting the importance of human factors in construction safety management. Possessing appropriate knowledge and skills is critical for workers in this regard. Safety knowledge enables workers to identify hazard, prevent, reduce, and eliminate potential accidents. On the other hand, safety skills are necessary for worker to carry out their task and responsibilities safely. The absence of either knowledge or skills can result in human error and construction accidents. This literature review aims to identify the various types of safety knowledge and skills that can help reduce construction human error and accidents. Through the analysis of several articles, the review found that safety regulation and accident record are essential safety knowledge, while hazard identification, communication, and leadership are crucial safety skills that can reduce construction human error and accidents.

1 Introduction

The construction industry is labour-intensive, and therefore, humans play an important role in it [1]. Managing construction safety and health depends significantly on the presence of humans [2], which is a crucial factor affecting safety management [3], even the success of construction projects is largely determined by the role of humans [4]. This highlights the significance of human involvement in construction safety management, indicating that their existence cannot be eliminated.

The construction industry is classified as a high-risk industry due to its diversity of activities, continuous change, complexity of the working environment, and poor working conditions [5-6]. The existence of risks is a leading cause of work accidents [7], that can result in fatal injuries and, in some cases, even death [8]. Most construction accidents occur due to human error [3, 9]. Therefore, reducing human error could help decrease the number of accidents.

Human error is the most significant factor causing construction accidents [10], and is responsible for up to 90% of accidents [11]. It cannot be entirely eliminated [12], but minimizing its occurrence is critical for improving safety [10]. The only way to improve safety in this aspect is by paying attention to the mechanisms that lead to human error [1].

Despite efforts to improve safety, the number of accidents in the construction industry remains high, due to lack of knowledge [13-14]. Safety knowledge can increase workers' ability to detect hazards, prevent, reduce, or eliminate the risk of accidents [14-16], and determine safety behaviour, as well as the link between safety climate and safety performance [14]. This indicates that adequate safety knowledge is necessary for safety improvement.

Safety skills are essential for workers to carry out their tasks and responsibilities [17], recognizing and managing hazards [18], to work safely [16]. Safety skills can also influence the implementation of safety management tasks and improve safety climate [1]. Workers with sufficient skills will work carefully to ensure occupational safety.

Through the analysis of several articles, it has been found that construction accidents caused by human error are often due to insufficient knowledge. Workers with knowledge deficiencies may have difficulty understanding the cause of accidents or even following safety procedures. In addition, inadequate skills can contribute to accidents by preventing workers from recognizing hazards and taking appropriate actions. Both knowledge and skills are essential for effective safety management, and the absence of either can lead to human error and construction accidents. This literature review aims to identify the various types of safety knowledge and skills that can help reduce construction human error and accidents.

2 Research methodology

Numerous research has been conducted on safety knowledge and skills, and a review of these papers has been undertaken to investigate how different types of safety knowledge and skills can reduce construction accidents caused by human error. The primary objective of this review is to identify the most effective

*Corresponding author: fajarsidiq.misbahul@gmail.com

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approaches to reduce construction accidents and improve safety outcomes in the construction industry.

2.1 Review process

The selection of papers for this review was carried out by searching various journal sources from reputable publishers such as Elsevier, ASCE, Taylor & Francis, and Emerald. The search process involved the use of keywords such as “safety knowledge”, “safety skill”, “construction accident”, and “human error”.

2.2 Selected journals

Nineteen journals were selected for review, comprising of five journals focused on safety knowledge, nine on safety skills, and five on the causes of human error. All the selected journals are ranked in the top quartile (Q1) across all categories of journals, indicating their high overall quality. The quality level of the selected journals is presented in three separate tables: Table 1 displays the quality level of the safety knowledge journals, Table 2 presents the quality level of the safety skills journals, and Table 3 showcases the quality level of the human error journals.

Table 1. The quality level of the safety knowledge journals.

Journal Publication	SJR	Quartiles Category	Number of Documents
Automation in Construction	2.4	Q1 in Building and Construction	2
Journal of Construction Engineering and Management-ASCE	1.07	Q1 in Building and Construction	1
Journal of Management in Engineering-ASCE	1.62	Q1 in Engineering (miscellaneous)	1
Safety Science	1.44	Q1 in Public Health, Environmental and Occupational Health	1

3 Result

The aim of this review is to identify various safety knowledge and skills that can reduce human error. Based on the selected journals, a classification system was used to identify different types of safety knowledge and skills. This identification process was divided into three categories: safety knowledge, safety skills, and the causes of human error.

3.1 Safety knowledge identification

Safety knowledge refers to the information obtained from understanding based on experience, habits, and learning [16]. It can increase workers' ability to detect hazards, prevent accidents, and reduce or eliminate risks [14-16], and determine safety behaviour, as well as the link between safety climate and safety performance [14]. Using these several definitions, an identification process was conducted to capture various types of safety knowledge that can reduce human error and accidents in the construction industry.

Table 2. The quality level of the safety skills journals.

Journal Publication	SJR	Quartiles Category	Number of Documents
Automation in Construction	2.4	Q1 in Building and Construction	1
Safety Science	1.44	Q1 in Public Health, Environmental and Occupational Health	4
Journal of Construction Engineering and Management-ASCE	1.07	Q1 in Building and Construction	1
Construction Management and Economics	0.95	Q1 in Building and Construction	1
Journal of Safety Research	0.97	Q1 in Safety, Risk, Reliability and Quality	1
Applied Ergonomics	1.13	Q1 in Engineering (miscellaneous)	1

Table 3. The quality level of the human error journals.

Journal Publication	SJR	Quartiles Category	Number of Documents
Journal of Construction Engineering and Management-ASCE	1.07	Q1 in Building and Construction	2
Safety Science	1.44	Q1 in Public Health, Environmental and Occupational Health	2
Automation in Construction	2.4	Q1 in Building and Construction	1

The identification of safety knowledge is a crucial step in ensuring the safety of workers in the construction industry. This process begins with a comprehensive review of several journals that focus on the discussion

of safety in the construction industry. In the previous chapter, five journals were reviewed to identify safety knowledge that could influence the safety management process. The findings from this review were then used to categorize the relevant safety knowledge according to its impact on safety management. The results of this safety knowledge identification process are presented in Table 4. By categorizing safety knowledge in this way, workers and organizations can better understand the various factors that influence safety management and develop effective strategies for improving safety outcomes in the construction industry.

Table 4. The findings of the safety knowledge identification process.

No.	Author	Safety Knowledge
1	Hadikusumo and Rowlinson [19]	a. Accident record b. Safety regulation c. Safety hazard recognition
2	Hallowell [20]	a. Database b. Record c. Regulation d. Experience
3	Le et al. [13]	a. Cause of accident b. Recommendation idea
4	Zhang et al. [21]	a. Safety rule and regulation b. Accident record c. Safety engineer experience
5	Xu and Zou [22]	Injury and incident data record

3.2 Safety skills identification

Safety skills are essential for workers to carry out their tasks and responsibilities [17], recognizing and managing hazards [18], to work safely [16]. Safety skills can also influence the implementation of safety management tasks and improve safety climate [1]. Through this several definitions, identification process was conducted to capture various type of safety skills that can reduce human error and accidents in construction industry.

A review was conducted on nine selected journals to identify safety skills that could impact the safety management process. Skills that were deemed relevant to safety management were classified as safety skills. The results of the safety skill identification process are presented in Table 5.

3.3 Cause of human error identification

Human error can occur due to a variety of factors, and the review process was carried out to identify the causes of human error and emphasize the impact of safety knowledge and skills on human error prevention. Table 6 shows the identification of the causes of human error.

4 Discussion

The identification process yielded various types of safety knowledge and skills, as well as the causes of human error. To synthesize the findings, similarities across different authors were analysed. The results were then categorized into different types of safety knowledge, safety skills, and causes of human error.

Table 5. The results of the safety skills identification process

No.	Author	Safety Skills
1	Hallowell and Hansen [23] Hasanzadeh et al. [24] Albert et al. [25] Pandit et al. [26]	Hazard recognition skill
2	Goldenhar et al. [27]	Leadership skill
3	Nilsson and Vänje [28]	a. Communication skill b. Risk assessment skill
4	Zamani et al. [29]	Safety communication skill
5	Fang et al. [30]	Safety leadership skill
6	Zou and Sunindijo [1]	a. Visioning skill b. Scoping and integration skill c. Emotional intelligence skill d. Interpersonal skill e. Leadership skill f. Scheduling skill g. Budget and cost management skill h. Quality management skill i. Risk management skill j. Procurement skill k. Social astuteness skill l. Interpersonal influence skill m. Networking ability skill n. Apparent sincerity skill

4.1 Types of safety knowledge

To gain a deeper understanding of safety knowledge, a thorough analysis of author opinions was conducted. This analysis revealed two distinct categories of safety knowledge: accident record and safety regulation. Four authors emphasized the importance of accident records as a critical source of safety knowledge, while three authors highlighted the significance of adhering to safety regulations. By examining these differing perspectives, it becomes clear that both accident records and safety regulations play an integral role in improving safety outcomes in the construction industry. A detailed overview of the identified types of safety knowledge can be found in Table 7, which provides valuable insights into the various factors that influence safety management and can help workers and organizations develop effective strategies for reducing the risk of accidents and injuries.

An accident record is a knowledge base of experiences that contains information on accident causation and precursor events [19, 21-22, 35]. It can also serve as an early warning of accidents, be used as a

basis for risk assessment, and inform risk response considerations [19, 35].

Table 6. The identification of the causes of human error.

No.	Author	Cause of human eror
1	Liao et al. [31]	a. Insufficient knowledge b. Access limitations c. Improper environment d. Memory failure e. Inadequate workplace layout f. Missing information g. Inadequate procedure h. Wrong sequence
2	Liu et al. [10]	a. Sequence errors b. Insufficient knowledge c. Missed observations. d. Inadequate planning e. Design failure f. Delayed interpretation g. Fault diagnosis h. Insufficient skills i. Inadequate quality control j. Inadequate plan k. Management problem
3	Fang et al. [32]	a. Unsafe behaviours b. Lack of knowledge
4	Karimi and Taghaddos [33]	a. Knowledge based education. b. Skill based experience
5	London et al. [34]	a. Deficiencies in knowledge b. Laps of skill

Table 7. Types of safety knowledge.

No.	Safety Knowledge	Author
1	Accident record	Le et al. [13] Hadikusumo and Rowlinson [19] Hallowell [20] Zhang et al. [21] Xu and Zou [22]
2	Safety regulation	Rowlinson [19] Hallowell [20] Zhang et al. [21]

In this study, safety regulations are defined as knowledge gained from safety work regulations that serve as guidelines for ensuring worker health and safety [13, 16, 19, 21].

4.2 Types of safety skills

To better understand the various safety skills that are necessary for improving safety outcomes in the construction industry, an analysis of author opinions was conducted. This analysis revealed three key categories of safety skills (Table 8): hazard recognition, communication, and leadership. Four authors emphasized the importance of developing hazard recognition skills, recognizing that the ability to identify and manage hazards is essential for preventing accidents and injuries. Additionally, three authors highlighted the significance of effective communication skills in ensuring that safety knowledge is properly shared and understood among workers, which can ultimately lead to improved safety outcomes. Furthermore, three authors emphasized the importance of strong leadership skills in promoting a culture of safety and encouraging workers to take responsibility for their own safety and the safety of others. By examining these similarities in author opinions regarding safety skills, it becomes clear that a multi-faceted approach is necessary for improving safety outcomes in the construction industry. Workers and organizations must focus on developing a range of safety skills, including hazard recognition, communication, and leadership, to reduce the risk of accidents and injuries and create a safer work environment.

Table 8. Types of safety skills.

No.	Safety Skills	Author
1	Hazard recognition skill	Hallowell and Hansen [23] Hasanzadeh et al. [24] Albert et al. [25] Pandit et al. [26]
2	Communication skill	Zou and Sunindijo [1] Nilsson and Vänje [28] Zamani et al. [29]
3	Leadership skill	Zou and Sunindijo [1] Goldenhar et al. [27] Fang et al. [30]

Hazard recognition skill refers to the ability to detect and manage hazards, whether in the moment before or during work, or based on prior knowledge gained from reviewing accident records [25-26].

Communication skill is defined as the ability for workers to exchange all forms of safety knowledge, both formally and informally, as an effort to prevent injuries or accidents, improve safety management, and enhance the safety climate [26, 28-29].

Leadership skill refers to each worker's ability to take responsibility for managing safety risks, carrying out safety duties, and enhancing the safety climate by creating a safety culture [1, 27, 30].

4.3 Cause of human error

Several authors have expressed similar opinions on the causes of human error, indicating that a lack of knowledge and skills can contribute to such incidents. This opinion was shared by three authors with respect to each cause. The findings suggest that human error can result from a deficiency in either knowledge or skills. Conversely, it is also suggested that an adequate level of knowledge and skills can reduce construction accidents due to human error. Table 9 provides a detailed overview of the identified causes of human error.

5 Conclusion

The analysis of the reviewed literature revealed that accident record and safety regulation are two types of safety knowledge that may help reduce construction accidents due to human error. Additionally, the

development of hazard identification, communication, and leadership skills were identified as crucial safety skills that can also contribute to reducing such accidents. Therefore, it is suggested that promoting the acquisition and application of safety knowledge and skills can enhance safety management and reduce the likelihood of human error leading to construction accidents.

Table 9. Cause of human error.

No.	Cause of human error	Author
1	Lack of knowledge	Liu et al. [10] Liao et al. [31] Fang et al. [32] Karimi and Taghaddos [33] London et al. [34]
2	Lack of skills	Liu et al. [10] Karimi and Taghaddos [33] London et al. [34]

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