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# Use of Digital Technology in Construction Health and Safety in India

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**Abstract**

**Introduction**: Globally, construction safety is important. This is one of India's most vulnerable unorganised labour categories. India must prioritize safety due to the industry's high labor intensity. Recently, the construction industry has shown interest in using AI to improve health and safety management. A new contribution to the field, this paper examines the key factors that enable AI in building health and safety management systems.

**Objectives**: The initial goal of this study is to add to the literature and start a discussion in India. This paper's second goal is to develop and test a comprehensive model to efficiently integrate AI into building health and safety management systems.

**Methods**: This study identified 25 success variables via qualitative literature review. Exploratory factor analysis was used to examine the 25 success criteria in a pilot study with 15 Indian construction workers. After collecting data from the pilot group, 258 Indian construction workers were given a longer survey. This study used qualitative and quantitative methodologies to design and evaluate AI integration success criteria for health and safety management systems.

**Results**: An EFA found 25 variables in six components. Since their eigenvalues are bigger than 1, these six components explain a lot of the observed variation.

**Conclusions**: This research designed and evaluated a complete model to easily incorporate AI in building health and safety management systems. AI needs knowledge, operation, administration, integration, dependability, and adaptability to be widely employed in health and safety management systems, says the study. Health and safety management. Research shows that each of these criteria strongly impacts health and safety management system AI adoption. Construction industry experts provided recommendations on how to use AI in health and safety management in the empirical research.

**Keywords**: Construction, Health and Safety, AI.

## 1. Introduction

Safety in construction is a global concern. In India, this is one of the most vulnerable categories of unorganised labour. Due to the high labour intensity of the industry, safety needs to be addressed thoroughly across India. A large number of workers are at risk of both occupational health problems and industrial accidents. Fatal accidents are four to five times higher in the construction sector than in manufacturing. It is imperative that an organisation cultivates a culture of safety as an essential part of its working environment. It needs to be as much a part of the management philosophy as making money. The aim should be to provide a safe working environment and work arrangements that support the health and well-being of employees, as this ultimately fosters a sense of loyalty and trust among employees. The need for workers (operators) to be trained in the latest tools, trends and techniques has increased with technological advances. This is necessary to ensure the safe operation of high-tech equipment and to prevent any threat to human life. With around 10 million people working in the construction industry, safety is a major concern. According to one report, there are 165 construction injuries per 1,000 workers.

It is a well-known fact that the construction sector is always reluctant to adopt new technologies due to lack of knowledge or information about the technology, the dilemma of using new technologies, their benefits and the cost of adapting them. However, the use of these technological interventions is seen as a powerful method of ensuring safety on construction sites. A variety of technologies are being used to ensure site safety in a global context, including sensor-based technology, information and communication technology, radio frequency identification technology and virtual reality. Technology offers an alternative means of improving and ensuring the safety of workers on construction sites. Technology may never be able to completely eliminate human error in the workplace, but it can effectively reduce the risk by providing the necessary training and promoting a safe working environment.

In recent years, the construction sector has seen a growing interest in the potential use of artificial intelligence (AI) to improve health and safety management. The application of AI technology to reduce hazards and improve safety outcomes on construction sites has been the subject of numerous studies. Prominent studies in this area have focused on the use of AI for risk anticipation, hazard identification and real-time monitoring. These studies have contributed significantly to our understanding of the feasibility and potential benefits of AI-based solutions for construction safety.

This study aims to make a unique contribution by carefully examining the critical elements that support the successful use of AI in construction health and safety management systems, although previous research has laid the groundwork. Our aim is to provide a deeper knowledge of the fundamental factors influencing the effectiveness of AI applications in this sector by conducting in-depth analyses such as Exploratory Factor Analysis (EFA). Through this study, we hope to fill the knowledge gap in this area and provide useful advice to practitioners and decision-makers in the construction sector as they begin the process of digitally transforming health and safety management.

Therefore, by shedding light on the factors that lead to the effectiveness of the application of AI in health and safety management systems, this study aims to contribute to the development of effective digital transformation strategies for construction projects. The main objective of this study is to identify the components that enable the efficient application of artificial intelligence in the digital transformation of state-of-the-art health and safety management systems in innovative construction projects. As a result of this study, a comprehensive framework for the appropriate application of AI in health and safety management systems can be established, which could lead to improved health and safety outcomes and reduced risk of accidents and injuries on construction projects. The results of this study can help policy makers and other industry stakeholders to make more widespread use of AI in health and safety management systems in the construction sector.

## 2. Objectives

Though the topic of health and safety is utmost important in construction sector, it is not studies vigour at least in Indian context. The first objective of the present paper add to the literature on the topic and initiate the discussion on such topic in the Indian context. The second objective of this paper is to create and verify comprehensive model to efficiently integrate AI in building health and safety management systems.

## 3. Literature Review

Abduljabbar et al. (2019) provide an overview of AI methods used globally to address transportation problems, mostly in the areas of traffic management, traffic safety, public transport, and urban mobility. To address those issues, Palaniappan et al. (2021) investigate the potential for combining AI with IoT. According to Buniya et al (2023), 20 components are needed to validate and improve effectiveness. These components were grouped into four constructs: site analysis, hazard and preventive control, management commitment and worker involvement, and health and safety training. The analysis verifies that safety programme components act as mediators in the interaction between safety CSFs and OPS. These findings can be applied to improve safety performance and provide a glimmer of hope for the implementation of safety initiatives in the Iraqi construction industry.

According to Williams et al. (2020), the health and safety culture of the Ghanaian construction industry is at the first level, or pathological stage. Despite the existence of codes of conduct and health and safety procedures, safety is not considered a major economic risk by Ghanaian contractors. As a result, neither management nor the majority of front-line workers emphasise the importance of integrating safety into all site activities. As a result, safety is no longer seen as an inevitable part of construction.

Al-Mekhlafi et al (2021) examined the relationship between driving performance and safety culture to develop a safety culture model. Safety culture has been identified in previous research as a determinant of safety problems. Following a pilot study, these issues were contextualised and organised into a theoretical model. Questionnaires were used to collect data from 307 Malaysian gas and oil tanker drivers. Partial Least Squares Structural Equation Models (PLS-SEM) were then used to statistically evaluate the final model of the study. According to the results, there is a significant relationship between safety culture implementation and driving performance, with an influence of 67.3%.

Othman et al (2021) conducted a study to identify the variables that might affect the implementation of safety procedures in construction projects in underdeveloped countries. After a thorough literature review, 21 critical success variables were identified. Sixteen semi-structured interviews were conducted with experts in the Iraqi construction industry to gain in-depth knowledge of these aspects. Interviewees confirmed the applicability of the success factors and highlighted the importance of a number of elements such as stakeholder involvement, management commitment, safety training and enforcement of safety laws and regulations. A new factor mentioned by respondents is technology. The findings can be applied to support the implementation of safety initiatives in developing countries and the construction industry in Iraq.

According to Mahmoudi et al. (2014), there are differences in the relative importance of the key components and the factors that influence them between the organisational and project levels. For example, commitment and leadership are the most important components at the organisational level, whereas risk assessment and management are the most important components at the project level. Their research showed that the framework is easy to implement and that by analysing the results it is possible to identify the root causes of the current state of organisations.

A collection of criteria was developed by Al Haadir and Panuwatwanich (2011), after reviewing and synthesising a number of factors found in previous construction safety research projects. These factors were then ranked using the Analytical Hierarchy Process (AHP), which was informed by the opinions of eighteen representatives of Saudi Arabian construction companies. Finally, the Pareto principle was applied to identify the seven most important success factors. These factors indicate the areas where companies should focus their efforts to improve safety levels through successful implementation initiatives.

According to Degas et al. (2022), contractors' safety management practices, such as failure to provide personal protective equipment, to hold frequent safety meetings and to provide safety training, are of great concern. The main elements influencing safety performance are 'reckless operations', 'poor safety awareness of project managers', 'lack of training' and 'poor safety awareness of senior management'. The report also suggests that the government should be more actively involved in setting up safety training initiatives and enforcing the law.

Abioye et al. (2021) identified and discussed some other avenues for research and unresolved issues related to AI in construction. While AI is being used more and more, other emerging technologies such as blockchain, IoT, BIM, quantum computing, augmented reality, cybersecurity and quantum computing are making AI even more relevant. They looked at some of the issues affecting the industry's adoption of AI, and came up with solutions to address them. In terms of relevant AI applications and research in the construction sector, the study served as a helpful resource for academics and industry professionals.

## 4. Methods

This study used a qualitative literature review technique to identify 25 factors that contributed to success. These were then validated by expert judgement. In a pilot study involving 15 participants from the Indian construction industry, the 25 success criteria were tested and the data analysed using exploratory factor analysis (EFA). Following the collection of data from the pilot group, 258 individuals from the Indian construction industry were given a longer survey questionnaire. The main objective of this study was to use both qualitative and quantitative methods to develop and evaluate success criteria for the integration of AI into health and safety management systems. We were able to include a large sample size and a range of opinions in our research through the pilot survey and full questionnaire survey. EFA was used to evaluate the data statistically.

## 5. Results

The results of an EFA show that 25 items (variables) are stored in six components. It can be inferred that these six components account for a significant portion of the observed variation because their eigenvalues are greater than 1. Component loadings provide insight into the degree of correlation between a particular item and a particular component. A strong correlation is indicated when an item has a high loading on a particular component. In this study, items with loadings of 0.4 or higher on a component are crucial. The EFA concludes that the 25 items can be grouped into six primary categories representing different concepts of AI. Inferences about the components are drawn from the items that have the highest significant loadings on each component; however, these conclusions may differ depending on the particular context, the experience of the researcher, and other factors. The AI Success Phase model identifies a number of critical success factors that must be met for AI to be successfully integrated into construction health and safety management systems. These factors can be grouped into six broad classes: intelligence, execution, control, management, assimilation, reliability and malleability. These factors are shown in Figure 1. The success factors for implementing artificial intelligence (AI) in health and safety in India were identified as intelligence, execution, control, management, assimilation, reliability and malleability.

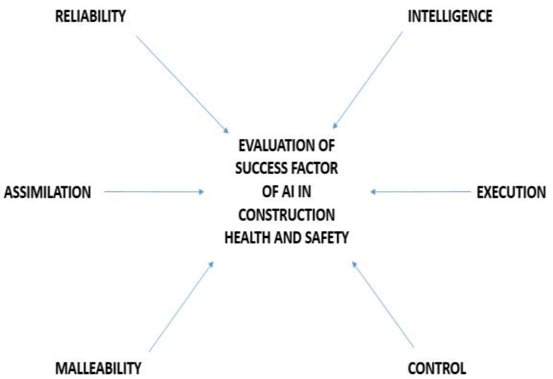


**Figure 1: Success Factor of AI in Construction**

The intelligence success factors identified highlight the importance of having reliable data before AI can be widely applied. Construction companies need to collect accurate, consistent and up-to-date data. It's also important to train employees and supervisors on how to get the most out of the AI system by drawing conclusions and analysing data. The concept includes essential components for the effective application of AI in health and safety management. The intelligence concept consists of three elements that emphasise the quality of data, the inventiveness of AI applications, and the adaptability and learnability of the system, in that order. The entire knowledge structure illustrates the need for continuous improvement and updating of artificial intelligence platforms to ensure their effectiveness in improving health and safety management systems. The model highlights the need to prioritise creativity, adaptability and data quality in order to smooth integration of AI into health and safety management systems.

The success factors identified in the Execution category emphasise the need for scalable, monitored AI systems that can deliver measurable results. A best-in-class AI system for the building sector should be able to handle massive amounts of data, be continuously evaluated for effectiveness, and deliver quantifiable results that are easy to monitor and verify. Ensuring that algorithms are well designed and data is properly managed is essential if you want to use AI to achieve the most amazing results. This success criterion highlights that reliable AI results require well-maintained algorithms and high-quality data. It also emphasises the importance of critically evaluating data sources and processing methods. Therefore, the initial framework for integrating AI into OSH management systems is well designed and has several essential components for success. In this context, improving and paying attention to data quality, adaptability, ongoing monitoring and evaluation, and measurable outcomes are essential for obtaining trustworthy and fruitful results from AI.

The success criteria identified in the Management category underline the importance of stakeholder involvement, compliance with relevant health and safety regulations and standards, prudent financial management and a commitment to ethics. The adoption process should involve supervisors, employees and anyone else who is curious about the new system used by the construction company and who has suggestions for improving it. Artificial intelligence in health and safety management systems should take into account moral concerns, such as the potential for discrimination or prejudice, and ensure that the system operates fairly and morally. Members of the target audience will be consulted to ensure that the system meets their needs and is consistent with the organisation's overall purpose. It is essential to check that the AI complies with all local, national and international laws, regulations and ethical standards.

The success criteria for assimilation into the AI system are emphasised by its identification with pre-existing health and safety management systems. The AI system must interact with other systems currently in place, exchange data and use various construction industry technologies. The framework emphasises the importance of evaluating the AI system's performance against pre-defined criteria. This is important to ensure that the AI system performs its tasks efficiently and delivers accurate results immediately. The effectiveness of the system and areas for development can be identified through the accuracy, timeliness and impact of the system on health and safety outcome assessments. The structure also emphasises the importance of teamwork within the operations, safety and information technology departments. This is essential to ensure that the AI system benefits the business and all its components. If the team works together to create the AI system, it can be better tailored to the needs of the company and its existing practices. Overall, the integration construct sheds light on why it's important to integrate the AI system with pre-existing health and safety management systems, how to evaluate the system's effectiveness, and how to foster interdepartmental collaboration.

The stated success criteria for the Reliability category emphasise the importance of reliable AI systems. The AI system must be designed to function under unforeseen circumstances and produce trustworthy results even when certain data is missing or contains errors. The framework incorporates three essential elements of a successful AI system: reliability and robustness, openness in decision making, and accountability for results. This is necessary to ensure that the system remains highly accurate as it adapts to new scenarios. It's important to remember that the system's credibility is limited by the data it receives. Inadequate or insufficient data can lead to incorrect conclusions. It is important to ensure that the system's decision-making process does not compromise the security or confidentiality of user information. It is important to ensure that the system's decisions are auditable and that it is held accountable for any errors or omissions. In this way, system failures can be identified and repaired to prevent future problems.

The importance of ease of use, continuous development and adaptability to changing project and environmental conditions is highlighted by the final success component of malleability. The AI system must have an easy-to-use interface that provides the required data in a timely manner. Finally, the system must be designed with continuous development in mind, from gathering user input to monitoring system performance. The main focus of formative architecture adaptability is the ability of an AI system to adapt to changing conditions. The three sub-constructs of this construct emphasise the importance of meeting user requirements, maintaining progress and adapting to changing conditions. Ensuring that the system is accessible to all stakeholders, regardless of their level of technical expertise, is crucial. A simple interface could facilitate the adoption of the AI system and its integration into existing procedures. Consequently, the system should be designed to take account of user input and be continuously monitored to identify and address potential problems. As regulations, project scope or data sources change, the algorithms and data inputs used by the system will need to be modified. Artificial Intelligence (AI) is revolutionizing the construction industry by providing novel opportunities to enhance productivity, security, sustainability, creativity, and competitiveness. But AI also presents certain difficulties for the public sector in terms of employment, security, ethics, and regulations on data quality. Figure 2 illustrates the difficulties, possibilities, and developing tendencies.

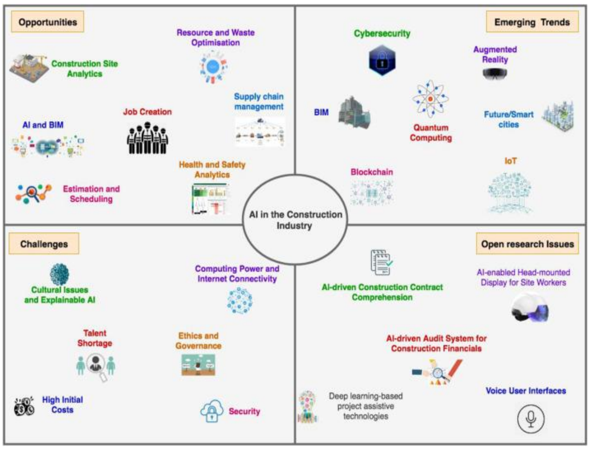


**Figure 2. AI in Construction Industry**

## 6. Discussion

Overall, this research aimed to create and verify a thorough model for the efficient use of AI in health and safety management systems in the construction industry. The study concluded that six basic constructs - knowledge, operation, management, integration, reliability and adaptability - are essential for the widespread use of AI in health and safety management systems. In health and safety management systems. Research shows that each of these factors has a significant impact on the rate at which health and safety management systems incorporate AI. A cross-section of construction industry experts participated in the empirical research, and their feedback was essential in understanding how to best use AI in health and safety management.

Using EFA, the researchers were able to establish a link between formative constructs and AI adoption. The findings of this research have significant theoretical and practical implications. For the use of AI in health and safety management systems, this research identifies six fundamental characteristics that are critical for theoretical contributions. These models provide a pathway for health and safety managers in the construction industry to follow when incorporating AI into their current workflows. The managerial implications of the study could have an impact on the construction industry. This guidance could help health and safety managers in the construction industry to make effective use of AI. Artificial intelligence in construction safety is not just a theoretical idea; it is already taking shape. We can expect projects to be completed faster, more effectively and with less risk as the sector embraces AI. AI's ability to promote sustainability in the construction health and safety industry is also in line with international environmental goals. All stakeholders must work together to overcome barriers and ensure that the full potential of AI in construction is realised. The construction sector is on the brink of a new era, and artificial intelligence (AI) will play an important role in this development.

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