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Technology Application in Enhancing Safe Working Condition in the Construction Industry

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Abstract: The construction industry is widely recognized for being very vulnerable to many risks, particularly those pertaining to health and safety. Despite the many efforts undertaken by all major industry players to increase awareness and raise the bar for health and safety in construction schemes, especially in developing countries, accidents still happen on construction sites. On both on- and off-site construction activities, safety processes, policies, and regulations may already be in place, but it is still up for debate how effective they are. This study, which is based on a traditional review, provides a review of several technology variables that have been investigated, proposed, and researched by many researchers globally. These variables are appropriate for creative and efficient use in working conditions on construction sites. These variables include safety inspection software, task-specific apps, digital safety auditing tools, and effortless wearable tech. It has been demonstrated that using technology can enhance overall construction safety management and lower the frequency of incidents that happen on construction sites. The information gathered can be utilized to pinpoint several of the applications which are applicable in developing nations' construction industries to guarantee secure working conditions. The proposed technology holds promise for drastically reducing the number of accidents that happen during on- and off-site construction operations, thereby enhancing working conditions and catapulting the construction industry in emerging nations to unprecedented heights.

Keywords: Construction industry; Construction sites; Construction safety; safety technology; Working condition

1 INTRODUCTION

According to several studies (Zou et al., 2015; Mo et al., 2018; Zou et al., 2017), the construction sector exhibits the highest accident rates of any industry. Construction sites are more challenging to manage than other industries because most jobs are repetitive and specified (Ganah et al., 2017). This is thought to be the reason for the high accident rates in the construction sector in comparison to other sectors like manufacturing and production (Choe et al., 2017; Melzner et al., 2014). Digital approaches have helped several industries enhance their processes (Ku et al., 2011). However, the construction sector is still highly dependent on human resources, which makes it more vulnerable to safety risks. The construction industry continues to have a high incidence of worker illness, accidents, and instances, even with government measures (Azhar, 2017).

Technologies are used for a variety of safety-related tasks, including obtaining real-time safety information, communicating safety information when needed, creating databases to hold vast amounts of data, and serving as a basis for risk assessment or accident forecasting (Nnaji and Karakhan2020). Advanced technologies can communicate with multiple assets and processes. Wearables, visualization, and mobile devices when combined can improve project certainty and understanding standards (Alaloul et al., 2020). While digital tools are being quickly adopted by the construction industry to change processes from start to finish, including design, execution, and closing, the industry is not keeping up with the adoption of these tools for construction safety. Historically, safety has been ensured by the observation, judgment, and experience of safety managers (Choudhry et al., 2008). In a similar vein, traditional safety-training learning modules are ineffectual due to a number of deficiencies (Pereira et al., 2018). Construction workers generally identify and resolve safety issues using their prior experience. Because such threats are hard to avoid and have the ability to thwart even the most well-thought-out safety program, one of the hardest things for workers to do is to notice and react when they are subjected to possible dangers and risks that are hard to predict (Chen et al., 2014).

Because construction sites are dynamic environments, there is a potential that workers may not be aware of changes to operating circumstances or newly introduced safety strategies, which could result in increased risks. Since safety personnel are not always on-site, construction workers are frequently left to handle the practical application of safety laws. This frequently leads to an inadequate application of mitigation approaches on identified dangers on-site. This article's goal is to provide information from published research on the variety of technologies available for off-site or on-site construction activities that protect worker health and safety. Finding out how technology is being applied to improve safe working conditions in the construction industry is the study's main objective. This is to comprehend how technology is applied in both developed and developing nations. A traditional literature evaluation is conducted to determine the technological applications as well as deployments that have been disclosed by other researchers across numerous studies.

2 CONSTRUCTION SAFETY AND TECHNOLOGY

Compared with different labor-intensive businesses, the construction site has the highest risk (Gunduz and Ahsan, 2018). Performance evaluation is crucial for enhancing safety management strategies in the construction industry due to the elevated level of risk involved.

When evaluating safety performance, undesirable outcomes including injury, death, and destruction of property are crucial (Cagno et al., 2014). When two contractors have the same quantity and kind of construction accidents, it is commonly presumed by traditional performance evaluation methodologies that their performance in terms of construction safety is equivalent. This, however, disregards the significance of the contribution connected to safety in building activities (El-Mashaleh et al., 2010). It is critical to find the adoption of technology predictions and evaluate whether they are of significance in influencing the acceptance of safety technology in construction, given the current level of industry fragmentation and the diversity of construction methods and approaches used by construction-related organizations.

Considering underinvestment and a lack of interest in high-tech advancements, the construction industry has been criticized for adopting new technologies more slowly than other industries. This has led to major inefficiencies (Yap et al. 2019). Several academics have investigated using technologies in contemporary construction to influence safety, given the urgent need to enhance work conditions and safety performance (Nnaji and Karakhan 2020). According to recent studies, there are even more advantages to employing cutting-edge technologies for safety management. These advantages include enhancing worker safety and enabling them to identify potential hazards (Akinlolu et al. 2020; Nnaji and Karakhan 2020). Though there is still some doubt about the safety technologies' long-term usefulness (Nnaji et al. 2020b), one significant factor contributing to their slow adoption rate is the inability to measure their potential directly in terms of efficacy (Nnaji et al. 2019). To reduce construction-related injuries and fatalities, safety management strategies have been the focus of researchers and practitioners. These methods include choosing safety best practices (Saurin et al., 2008), improving organizational leadership and safety culture (Weaver and Edrees,2017), improving hazard recognition (Albert et al., 2013; Perlman et al., 2014), job hazard analysis

(Rozenfeld et al., 2010), and other behavioural techniques (Afuye et al., 2022). These safety measures, while valuable and advantageous, are administrative measures with limited efficacy and dependability. More comprehensive safety measures must be put in place if the construction industry is to see a decrease in the number of fatalities and major injuries. New methods, including using technology, are becoming more and more common since they may make workplaces safer and lower the number of accidents and fatalities (Hollnagel, 2018). According to several studies, safety performance has significantly improved in high-tech sectors (Gill and Shergill, 2004). The greater use of technology in these industries is partly responsible for the improved safety performance. Various stakeholders are striving to enhance the adoption and utilization of technology in the construction sector to boost safety performance.

3 RESEARCH APPROACH

It is imperative to identify strategies for improving the integration of technology into safety management practices within the construction industry, particularly considering the development or modification of new technologies for safety-related purposes. This study aims to give a framework for safe working conditions in the off site and on-site operation in the context of construction industry regarding technology. Secondary data was used in the development of the suggested technological application to improve safety while working in the construction business. The baseline for this study work's systematic review was this secondary data. Using the terms "construction sites," "construction industry," "working condition," "construction safety," and "safety technology," the Scopus databases and ISI Web of Science were searched for relevant literature. These databases were chosen in accordance with Guz and Rushchitsky's (2009) contribution, which claims that the ISI Web of Science and Scopus archives are the most popular sources of research papers related to scientific fields. During the search, more than 300 papers were located; they were thoroughly examined to see whether they were relevant to the study's primary focus. 95 articles in all met the criteria to be considered for this analysis; however, because several research papers overlapped, the search was restricted to publications made between 2010 and 2022. The search was limited to publications, though, and it was honed even more by comparing it to conference and journal papers. Ultimately, 41 published publications that discussed technological application studies of developed and developing construction sectors globally were found to be relevant. The term of "technology application" in the study thus encompasses all indicators utilized to evaluate safe working conditions on construction projects within the investigated construction industry. As safety and health have become major project management team responsibilities, this paper provides an overview of these technological variables that have been put forth and studied by numerous researchers worldwide. This technology includes safety inspection software, task-specific apps, digital safety auditing tools, and effortless wearable technology. These variables are suitable for effective implementation and creativity on working conditions on construction sites. The framework that was created for the application of technology to enhance safe working condition in the construction industry is conceptualized and illustrated in Figure 1.

4 TECHNOLOGY APPLICATION IN CONSTRUCTION SAFETY AND HEALTH

4.1 Safety Inspection Software

Site safety inspection is a critical part of measuring and evaluation that demonstrates the efficacy of current systems or initiatives, according to Feng (2013); Hinze and Godfrey (2003). Despite the significance of the site safety inspection procedures, very few studies have investigated them in detail. According to Lee, Tsai, Lin, and Kang (2012), inspectors frequently use paper and a pen to record their site safety checks. The outdated paper-based inspection method makes it difficult to maintain and evaluate inspection results. It also requires extra work to input descriptions in writing into a computer system, which is error-prone and time-consuming. A move has been made to enhance safety performance by integrating information technology (IT) advancements into site safety inspections, considering the increasing acceptability of IT use in construction management (Taneja, 2010). These initiatives could be split into two groups. The goal of the first category is to use sensing technology to fully automate the safety surveillance process. The goal

of the first category is to use sensing technology to fully automate the safety surveillance process. While the second goal enable quick decision-making on building sites, sensors are set up to collect real-time safety – related data from the surveillance set up. The autonomous safety alarm system created by Teizer (2010) is a typical illustration of this kind of use. The technology monitors the movement of people and large pieces of machinery and warns people when they approach a potential collision zone. To make the on-site and post-inspection data entry related to safety more efficient, several mobile inspection devices have been created. In 2005, Sunkara created a tablet PC application that lets users take images of the risks present on their work site and generate reports of inspection with photos of pertinent hazards, accident prevention tips, and the hazards that have been identified. In this way, Lee et al. (2012) created the iSafe safety audit system for the iPad. The system automatically generates inspection reports and offers a common inspection template to facilitate the collecting of site safety data. With the invention of inspection software, input descriptions in writing into a computer system, which is error-prone and time-consuming are already being put to check in offsite and onsite inspection. Most of the site clerks, residence engineers and residence builders in the developing countries are still frequently using paper and a pen to record their site safety checks which are prone to lot of human error. Adopting the safety inspection software will ease their task and it will improve safe working practices and condition of the construction site.

4.2 Task-Specific Apps

Timely information delivery would usually be less necessary if the interface for accessing information and output were any less thorough, task-specific, and user-friendly. Additionally, a variety of media (including text, photos, videos, and augmented reality) and technologies (such radio frequency identification (RFID) and barcodes) may be incorporated into the output. The user needs to find the asset that needs maintenance and gain access to the data processing and rule-based system (DPRBS) to obtain task-specific safety information. Two background processes will take place according to the values that apply to that particular asset right now. First, relevant safety-related information will be supplied to the end user interaction prior to the finalized safety process. Second, the interface will establish a task-specific protocol by posing a series of brief questions to the user on the asset that needs to be maintained, the situation, and the surrounding area. Like inquiry-based learning strategies, a question-based method encourages staff members to assess the safety plan in advance rather than after the activity is finished. Depending on the selected asset and the user's response, the facility management (FM) worker will receive an output for the safety procedure (Wetzel and Thabet, 2015). Introducing this task-specific applications to construction activities in on-site and off-site particularly in the developing nations will allow construction workers to be free from ambiguity and be specific and firm in task delivery. Task-specific apps will enhance a safe working condition in the construction industry.

4.3 Digital Safety Auditing Tools

Real-time surveillance for job progress tracking, quality data gathering, accident detection, and cooperative communication is made possible by this technology (Nnaji et al. 2020a). Tools for safety audits primarily offer capabilities for documenting inspection findings. For instance, iAuditor provides inspection reports that may be printed or stored in a digital format and offers models of site inspection checklists for user selection and customization. A project's safety performance is often indicated by an overall safety score in an inspection report. iAuditor cannot evaluate the data gathered (e.g., to spot trends of unsafe working conditions or behaviours) or combine it with other project performance statistics because it does not provide integrated communication with subcontractors (Lin, Tsai, Gatti, Lin, Lee, and Kang, 2014).

Digital safety auditing tool is not human hence the auditing tool is not emotionally neither bias but provides precise inspection reports that offers models of site inspection checklists for user selection and customization. Introducing this digital safety auditing tools to construction industry in the developing nations is a right step in a right direction.

4.4 Effortless Wearable Technology

The development of wearable technology is still in its infancy. Anything that can be worn to carry out daily activities is referred to as wearable. According to Luczak, Burch, Lewis, Chander, and Ball (2020), wearables, wearable devices, or wearable technology are tiny electronic and mobile gadgets and computers with wireless communication capabilities that are incorporated into clothing, accessories, or gadgets that are designed to be worn upon the human body. Wearables also include invasive forms like smart tattoos or microchips. To put it another way, a wearable device is any computer that has the sensors needed to manage, evaluate, or analyse one or more wearer-specific health indicators. Wearable technology includes gadgets like wristbands, smartwatches, chest bands, and other textile-based sensors. The devices are connected to collect data, observe user behaviour, and subsequently use the collected and stored data to customize the user's experience to meet their needs. Wearables with specific purposes in mind may have multi-sensor features that can be tailored for that use. Wearables need to be multipurpose, lightweight, cozy to wear, and understated in appearance. The essential tasks that wearables should perform include sensing, analysing, storing, communicating, and applying. Data processing may occur nearby the wearer or at a different location (Atianashie and Chukwuma, 2023). Additionally, real-time information from wearable devices has been used to offer customized safety monitoring, including proximity detection, ambient sensing, physiological monitoring, and location tracking (Awolusi et al., 2018)

Advancement in construction technology is still at the kneel in the developing nations context. This potent lot of fatality and hazard in the construction activities undertaken either off-site or on-site operation. Adopting this effortless wearable technology will transform the industry to a safe working environment. These wearable devices will be able to sense, analyse and communicate the surrounding dangers either cause out of ignorance of the construction worker(s) or force majeure.

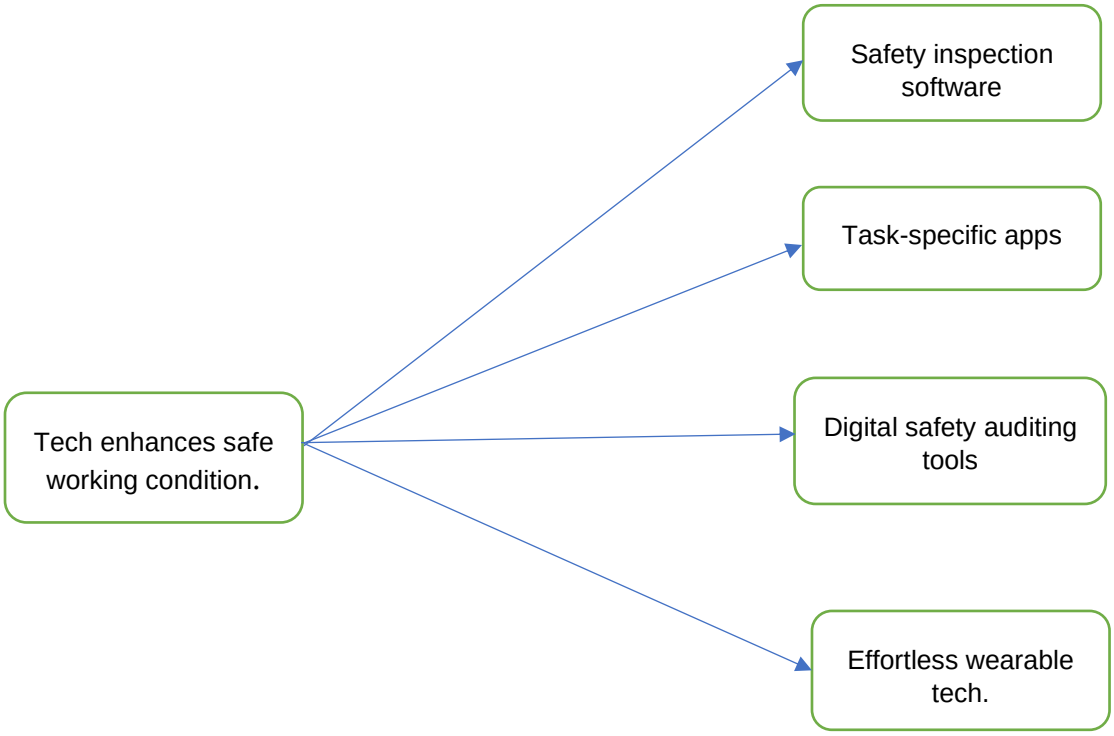

Figure 1. A conceptual framework of technology to enhance safe working condition.

5 CONCLUSION

Globally, a large range of industries, including the construction industry, now use technology. Numerous research on the use of technology in various elements of safety and health, including on-site and off-site

operations and practices, safety information exchange, safety training, and site surveillance and oversight, have demonstrated this.

However, the use of technology was thought to have great advantages for the safety and health components of construction generally, not everyone agreed that technological advancements were feasible, even though some sectors of the construction industry were already considering implementing some of the proposed systems in developing countries. If on-site and off-site safety management are properly implemented, the adoption of the technology variables (safety inspection software, task-specific apps, digital safety auditing tools, and effortless wearable tech) suggested in this paper will reduce the number of accidents occurred. Even though a lot of study has been done on how to improve construction safety in developing nations, very few, if any, of these studies have particularly looked at the technology that may be used to help with the creation of a construction safety management system. This is because traditional reviews of the literature have not been thoroughly examined in this area. Quality inspection and controlling via friendly interface is at abysmal in developing nations context. Introducing and adopting electronic user-friendly interface into construction industry activities in the developing countries would be beneficial. Although they are not the only answers, they can offer safety professionals and construction workers a helpful way to keep track of, document, and learn from interactions between the designed model or system and the workers and staff on a construction site.

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