An Exploratory Study into UK Construction Industry Response to Digitalised Health & Safety Management

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Abstract

Purpose—Workers are susceptible to high accident rates due to the nature of work in the construction sector. To improve the work environment, there have been calls for adopting digital technologies (DT) in health and safety (H&S) management. However, the response and readiness to adopt these technologies in various countries are unknown. This study investigated the UK construction industry's response to adopt digital technologies for H&S management.

Design/methodology/approach — A qualitative research approach was adopted to gather the required evidence to achieve the research aim. Twenty UK-based construction professionals with five to thirty-three years of experience were purposively selected from the UK (England, Northern Ireland, Scotland and Wales) and interviewed. The data were analysed using thematic analysis.

Findings — The study's findings revealed that the response of the UK construction professionals to the use of DT for H&S management is that of resistance to new technologies, low knowledge and readiness in the workforce, varying receptiveness (due to factors like workers' age and size of company, concerns about reliability and data security, high implementation costs, and fears about job security), and economic pressures, which are potential drivers of innovation.

Original/value—This is among the first qualitative studies to empirically explore the perspective of key stakeholders in the UK on the use of DT in health and safety management. It contributes to the future adoption of DT in health and safety management in the UK.

Keywords: Adoption, Construction Industry, Digital Technologies, Health and Safety, Response

Introduction

It is common knowledge that the construction sector globally is infamous for its poor health and safety records, contributing 20-25% of all fatalities among workers in the UK and the USA (Ganah and John, 2023), with 59% of construction workers in Ethiopia, Gambia, Ghana, and Uganda reporting occupational injuries (Kinteh and Bass, 2023; Agyekum *et al*., 2022). In some cases, they have the second worst record across all the industries, just after agriculture and fishery (HSE, 2024). Despite the legislative reform in health and safety (H&S) and the continuous call for improvement, the construction sector remains unacceptably hazardous in many regions of the world (Ganah and John, 2023; Loosemore and Malouf, 2019). Consequently, several studies have advocated for the use of digital technologies to improve H&S in the construction industry (Maali *et al*., 2024; Ganah and John, 2023; Perera *et al*., 2022; Ribeiro *et al*., 2022). Digital technologies are information and communication technologies encompassing hardware and software used to manage and manipulate data electronically (VIDA, 2024; Fluckiger and Zabban, 2023). According to Johnstone *et al*. (2022), digital technologies are tools, systems, and devices used to generate, create, store, or process data enabled through microprocessors programmed to perform various functions.

Various researchers (Maali *et al*., 2024; Ganah and John, 2023; Perera *et al*., 2022; Ribeiro *et al*., 2022; Xu *et al*., 2021; Antwi-Afari *et al*., 2019; ;) recommend the use of digital technologies such as building information modelling (BIM), wearable devices, unmanned aerial vehicles (UAV), immersive technology (ImT), virtual/augmented reality (VR/AR), and artificial intelligence (AI) in the construction industry to improve H&S. These technologies have contributed to H&S planning, training and education, and management improvement efforts in countries and companies that have implemented them (Agyekum *et al*., 2022). Despite the several benefits, the adoption of digital technologies in UK construction, H&S management remains relatively slow compared to other sectors (Ganah and John, 2023; Xu *et al*., 2021). The number of fatalities recorded in the UK construction sector increased from 39 persons in 2022 to 45 in 2023 (HSE, 2024).

Some studies have explored the use of digital technologies (DT) in UK construction H&S management. They highlight the potential benefits and challenges of implementing DT in this context. For instance, Kassem *et al*. (2017) and Davila Delgado *et al*. (2020) have shown that the use of virtual reality (VR) and augmented reality (AR) can enhance safety training and hazard identification on UK construction sites. Additionally, the implementation of wearable technologies has been investigated for their potential to monitor worker health and environmental conditions in real-time by researchers such as Valero *et al*. (2016). These technologies can provide valuable data for proactive risk management and incident prevention (Chung *et al*., 2020). Building Information Modelling (BIM) has also been studied for its role in improving safety planning and design, allowing for better visualisation and identification of potential hazards in the UK by Swallow and Zulu (2019).

The potential benefits of using digital technology (DT) in construction health and safety (H&S) have been extensively explored in existing literature. However, despite the evidence supporting its effectiveness, the full adoption and implementation of DT in the construction sector have yet to be realised (Dobrucali *et al*., 2024; Tender *et al*., 2022). The slow pace of adoption raises questions about the response and readiness of the construction industry towards embracing digital technology. While some scholars have examined the use of DT in the construction sector, both within and outside the UK, most of these studies focus on the entire industry. For example, Jallow *et al*. (2022) and Shibeika and Harty (2015) explore DT usage in the UK construction industry, but their focus is not specifically on the response of the sector to the use of DT in health and safety management.

Similarly, studies from outside the UK, such as Ribeiro *et al*. (2024) in Brazil and Musarat *et al*. (2023) in Malaysia, also lack specific emphasis on the response of the sector to the use of DT in health and safety management in construction. Despite efforts by construction management scholars to develop models for assessing DT adoption response and readiness in the construction sector, most of these studies also have a broader focus (Ribeiro *et al*., 2024; Chen *et al*., 2023; Trask and Linderoth, 2023; Oke *et al*., 2018), limiting our understanding of the response of the sector on the use of DT in health and safety management. Though a few studies have explored the intersection of DT and health and safety in construction (Dobrucali *et al*., 2024; Daniel *et al*., 2024; Trask and Linderoth, 2023; Tender *et al*., 2022), the majority of these are based solely on literature reviews, highlighting a significant gap in empirical research on the subject. Hence, there is a need for more comprehensive studies to understand the response of stakeholders to the adoption of DT for health and safety management in the construction sector. This is critical as the success of DT implementation relies on the technology itself and the industry's response to its adoption (GIRI, 2019). To achieve this goal, the study addresses the following research questions:

RQ1. What is the current response in the UK construction industry to integrating digital technologies into health and safety management?

RQ2. What factors contribute to the slow adoption of DT in Health and safety management?

Overall, this study contributes to our understanding of the UK construction industry's response to the use of DT for health and safety management and provides insights for future developments in this area.

Literature Review

Overview of Global Construction Health and Safety Management and Records

Construction work is known for being carried out in hazardous situations and poor and unpleasant working conditions. According to the International Labour Organisation (ILO), construction workers are constantly exposed to hazardous substances, hazardous atmospheres, radiation dangers, noise, and vibrations (Bagir, 2021; Akinlolu *et al*., 2020). Umer *et al*. (2017) corroborated this, noting that the construction industry is one of the major sectors with the highest rates of occupational injuries and fatalities. The primary risk factors contributing to accidents and occupational injuries include incorrect posture, heavy machinery, falls from height, heavy lifting, heavy carrying, and poor weather and wind conditions (Bagir, 2021). The safety, health, and well-being of workers are strategies for economic development because they boost productivity, quality, and project performance (Nnaji and Karakhan, 2020).

According to the US Bureau of Labour Statistics (BLS) report in 2019, 5,333 fatal occupational accidents occurred in the United States, with 1,061 occurring in the construction industry (U.S. Bureau of Labour Statistics, 2019). According to Eurostat's reports, 3,332 fatal incidents occurred in Europe in 2018, one-fifth of which occurred in the construction industry (Eurostat, 2020). Hamid *et al*. (2019) reported that in 2018, the Malaysian construction industry had the highest number of occupational deaths in any sector, with the construction business responsible for 118 deaths (45.4%). In 2019, construction accounted for one in every five workers' deaths in the private sector, accounting for about 20% (1061) of total worker fatalities (U.S. Department of Labour, 2021). In 2020, the cost of injuries in the construction business grew by 34% compared to 2018, and the fatal injury rate in the construction industry was four times higher than that of other industries (Health and Safety Matters, 2022). The global rate of accidents, injuries, and deaths on construction sites is nearly 40% more than in other industries (AL-Sahar *et al*., 2021).

Construction Health and Safety Management in the UK

In 2023/2024, fifty-one fatalities were recorded in the UK construction sector (HSE, 2024). In the UK, the construction industry, compared to other sectors, had the most significant rate of fatal workplace injuries (Land, 2024). These statistics are fundamental to the common perception that construction sites are dangerous workplaces. They are considered places of unsafety. Indeed, it could be argued that the industry labels itself unsafe; the common sign 'Danger! Construction Site' at entrance gates and perimeter hoardings of construction sites characterise them as inherently dangerous (Sherrat *et al*., 2013).

Construction-related illnesses and injuries cost the British economy GBP 16.2 billion in 2018-2019. Most of these costs—59%, or GBP 9.56 billion—were borne by those who were injured or unwell (Musarat *et al*., 2023). Additionally, the industry recorded 69,000 industry-related illnesses, many of which required lengthy absences from work (FirstMats, 2023). According to Xu *et al*. (2021) and Farmer (2016), in addition to H&S issues, the UK construction industry (just like others) still faces significant challenges in terms of productivity and efficiency, resulting in the growing need to invest in and adopt innovative technologies to improve performance and deliver better outcomes. Xu *et al*. (2021) further noted that the traditional means of monitoring and inspection procedures make it challenging to cover entire sites while observing all personnel. Xu *et al*. (2021) further observed that earlier conventional construction H&S methods used paper-based hazard recognition systems, which hamper prompt risk communication. These shortcomings highlight the need to address safety concerns and adopt effective preventative tactics in the UK construction sector (FirstMats, 2023).

Although H&S measures are widely accomplished within the manufacturing industries, in comparison, conditions in the construction industry cannot be controlled as a "pure" production process; as such, H&S management is paramount (Ganah and John, 2017). Unsurprisingly, the UK government does not tolerate the existing rates of fatalities recorded in the industry, with the industry and academia noting that even 'one death is too many' (Sherrat *et al*., 2013). Thus, constant efforts are employed to reduce accidents and incidents, alongside legislation and regulations to improve site safety.

Digital Technologies for Managing Construction H&S in the UK

Despite lagging behind other industries such as banking, finance, retail, and healthcare, in adopting digital technologies, the construction sector has gradually embraced innovation (Abioye *et al*., 2021). Various digital tools and technologies are available to enhance efficiency, productivity, and safety on construction sites, as noted by Ganah and John (2023). Razi *et al.* (2023), Choi *et al*. (2020), and Li *et al*. (2018) have established that DT can be utilised to manage H&S and predict potential risks and hazards that may develop at various construction stages. Technologies such as BIM have been identified for their role in improving safety planning and design, allowing for better visualisation and identification of potential hazards on construction sites in the UK (Swallow and Zulu, 2019). Yang *et al*. (2021) further reported that H&S technologies are gaining popularity in the building industry. To minimise construction accidents and improve site H&S, technologies such as virtual and augmented reality (VR and AR), BIM, unmanned aerial vehicles (UAVs), wearable devices, and the Internet of Things (IoT) have been created; resulting in improved learner engagement and experience of real-world issues (Li *et al*., 2018). Some of the digital technologies and their application in H&S management in construction are shown in Table 1.

Insert Table 1 here

The notion of response and readiness for the adoption of any technology is best understood from the existing adoption of technology and readiness frameworks and models. One of the frameworks that can be used to understand the drivers and barriers to the adoption of technology is the ***Technology Acceptance Model*** (TAM) developed by Davis (1989). TAM explains how users' acceptance of a technology is based on their perceived ease of use and perceived usefulness of such technology (Davis, 1989). For the drivers of adopting digital technology for H&S management, in terms of their perceived ease of use, construction stakeholders, particularly workers and managers, need to make them user-friendly and integrate seamlessly into workflows. For perceived usefulness, stakeholders must see the benefits of digital tools in improving safety outcomes and efficiency to accept them.

Regarding the barriers to digital adoption of technology for H&S management, lack of familiarity with the digital tools may trigger negative perceptions regarding ease of use. Meanwhile, resistance to change from traditional H&S methods may be a barrier to perceived usefulness. These complexities may drive or hinder the adoption of digital technology for H&S management in the construction industry.

In the UK, the implementation of digital devices, such as wearable technologies, has been investigated for their potential to monitor workers' health and environmental conditions in real time (Valero *et al*., 2016). Maali *et al*. (2024) and Ribeiro *et al*. (2022) also reported that wearable gadgets such as smart headgear or helmets, with features such as unique glasses, 4D augmented reality, and a transparent visor, can help prevent falls, electrocutions, and other catastrophes. Some organisations in the UK have delved into implementing AI to enhance H&S in construction; for example, a Tier 1 UK innovation organisation is developing AI-enabled hard hats to improve on-site communication and information sharing. This technology aims to replace phone calls and paper drawings by providing voice-activated and visual information. Users of the technology can issue commands like "Show me building plans" or "Show me construction sequence". This technology works like Google Home and Amazon's Alexa. Once finalised, the technology will be used by contractors, clients, and the entire supply chain (Jallow *et al*., 2022).

Despite the foregoing advances, studies have scarcely explored the response of UK construction professionals toward adopting digital technologies for H&S management. This aspect is critically important as an enabler of the effective implementation of the technologies.

Research Method

Our study adopted a qualitative approach to explore the construction industry's readiness to adopt digital H&S management technologies in the UK. According to Mani *et al*. (2016), the qualitative method is appropriate for understudied situations. The qualitative approach is also considered appropriate when seeking deep insight into a problem based on the experiences of the research participants (Byman, 2016). A review of related literature was first conducted to get an overview of the research topic. Grant and Booth (2009) established that a review is significant in identifying what has been accomplished previously, allowing for consolidation, building on previous work, and identifying omissions or gaps. Secondary information was sourced from scientific databases such as Elsevier Scopus. The search used the relevant keywords "construction industry", "UK construction industry", and "UK H&S professionals". Relevant publications were identified and reviewed.

The interview guide was compiled to address the RQs. The interview questions were divided into three sections: (a) demographic information, (b) current receptiveness of the UK construction industry for DT to be used in construction H&S management, and (c) factors contributing to the slow adoption of DT in H&S management.

Purposive sampling was used to choose interview participants for the collection of primary data. This sampling technique allows for participants to be selected based on their subject-matter expertise or years of experience in the field of research (Marshall and Rossman, 2014), which was a primary criterion for their selection. The first contact was by emailing the participants, explaining the study, the importance of their contribution, and the scheduled interview sessions. A semi-structured (open-ended) virtual interview was then conducted with 20 construction professionals operating across the UK. The number of participants was adequate, as studies like Sim *et al*. (2018) and Guest *et al*. (2006) reported that sixteen or fewer interviews were sufficient to garner information from a homogeneous group to reach a saturation point. However, in this study saturation point was reached on the 19th and 20th interview and the interview was discontinued. The saturation point is the point where no new themes emerge from the analysis of the interview. Semi-structured interviews are notably adaptable and user-friendly (Ebekozien *et al*., 2023). The interview structure allowed the professionals to provide information on the current state of the UK construction industry on the subject matter of the study.

All the participants agreed to participate by signing a consent form that described the study's purpose and the voluntary nature of the study. Our university's faculty ethics committee approved the research project before the commencement of the data collection. Due to the participants' hectic schedules, the interview process was conducted virtually via Microsoft Teams using voice calls. To gather the required data, an average of 60-minute interviews were conducted with each participant. The participants had between 5 and 33 years of experience in the UK construction sector. . The interviews were conducted in between January 2024 and September 2024.

The data collected was then inductively analysed using thematic analysis. These were done to categorize the interview transcripts according to the emerging ideas. According to Naeem *et al.* (2023), thematic analysis is generally flexible and can be applied across various qualitative data types and research questions, making this approach widely applicable. The process allows for a deep dive into the data, enabling researchers to uncover nuanced patterns and meanings that might not be apparent through other methods. Figure 1 shows the research framework.

Insert Figure 1 here

The thematic analysis involved analysing the individual responses to have a complete perspective of all the data gathered. The audio recording was transcribed, the text was read, and short notes were taken and stored in a transcribed file. Second, labels were allocated to the interview questions, such as the current receptiveness of the UK construction industry to DT for H&S, enabling codes to be constructed for each research question. Third, a coding method was determined. There are two main types of coding strategies: descriptive and interpretive. Saldaña (2021) stated that descriptive coding summarises the primary topic of a passage of qualitative data in a word or short phrase and is often used in the initial stages of data analysis to categorise data at a basic level. Merriam and Tisdell (2016) defined interpretive coding as a technique that goes beyond description to include the researcher's interpretation of the data's meaning, involving a deeper level of analysis and often considering the context of the data. As a result, the study employed descriptive-focused coding since the goal was to elicit responses that directly addressed the interview questions. The next step was the coding process. The transcript file was searched for relevant responses that addressed the labelled interview questions. A code was formed and associated with an appropriately labelled interview question when relevant material was discovered. Related responses were added to previously established codes, and if a response was unrelated but relevant, a new code was generated and tied to the research question it addressed. Themes were based on phrases, words, or brief statements that indicated a group of connected responses to the study questions from the participants. The research team reviewed and agreed on the final themes. The results and discussion section presents and discusses the key themes generated from the study.

The 20 interview participants were assigned codes P1 to P20, as shown in Table 2, which shows their demographic information.

Insert Table 2 here

Results and Discussion

Response of the UK's Construction Industry to Digital Technologies in Construction Health and Safety Management

Three main themes emerged from the thematic analysis on the responsiveness of the UK's construction industry to digital technologies in construction H&S management. The themes are (1) Resistance to adoption, (2) Low knowledge and readiness in the workforce, and (3) Varying levels of receptiveness.

Resistance to adoption

Several participants expressed concerns about adopting digital technologies in the construction industry. One participant, **P6**, stated that *"some clients are resistant to implementing new technologies because of the difficulties in getting certain software approved at client sites*." This finding is quite significant because clients usually have a significant role in conceiving and funding projects, and their resistance to adopting digital technologies presents a hindrance to using those technologies on their projects. This finding aligns with the findings from Sepasgozar and Davis (2018), who identified organisational approval processes as a significant barrier to the adoption of technology.

P12 expressed that *"as an industry, there is a fear of what is this technology, is it something we need to be afraid of, is it something we need to embrace? There is always this kind of argument that, okay technology is great, but it has issues we have to figure out and overcome."* This finding suggests that the concern or fear construction stakeholders have about a technology translates to uncertainty about its usage in construction projects. These concerns and fears are often passed on to most stakeholders (clients, professionals, and the workforce) without proper investigation and verification. This finding corresponds with that of Widén (2006) in the research on innovation diffusion in construction, which found that perceived risks and uncertainty often delay the acceptance of technology.

P16 stated that, *"Digital safety tools just slow us down. Workers have been doing things the same way for decades and know what they are doing. Learning new apps and systems takes time away from actual work. Plus, reliable internet connection is sometimes spotty on many job sites, so digital tools are not always practical."* This finding shows that being used to a way of doing things impedes the introduction of new alternatives, even when such alternatives are better than the status quo. This response is in tandem with the findings of Li *et al*. (2018), who established that there are concerns, especially among building industry specialists, about the complexity of digital technology installation, the intricacy of new systems, and the possibility that technology would supplant conventional safety procedures. Research by Ganah and John (2023) and Xu *et al*. (2021) further noted that the adoption of digital technologies in UK construction H&S management has been relatively slow compared to other sectors. These findings confirm that practical implementation issues and underlying cultural resistance to change are the leading causes of the construction industry's cautious approach to new technologies (Hwang *et al*., 2022).

Low knowledge and readiness in the workforce

Participants highlighted a general lack of knowledge and readiness for adopting new technologies in the construction industry. According to **P4,** *"When less than 10% of people have adopted just BIM technology, they would claim they are doing very well. In the UK, the readiness is not high."* **P8** said, *"In the United Kingdom, the level of AI and Digital Technology (DT) knowledge and readiness within the construction industry workforce and management is generally low to moderate."* **P7** added, *"People working on site have less experience with or knowledge of these systems in my experience. Moreover, yes, you know, they could benefit from more training and, you know, a better appreciation generally of the benefits of these systems."* **P19** stated, *"the industry has not invested enough in developing digital skills. We face a significant skills gap where traditional construction expertise does not match the new digital requirements, and finding workers with both construction experience and digital literacy is challenging, and training programs are not keeping pace with technological changes."*

The findings of our study show that although digital technologies improve construction health and safety, their knowledge among the construction workforce and the readiness for their adoption in the UK construction industry is still low. These are also related to the expertise of the construction workforce in using the technologies, as there exists low expertise among the construction workforce. The findings of our study align with those of Taher (2021), Alaloul *et al*. (2020), Forcael *et al*. (2020), and Oesterreich and Teuteberg (2016), who reported the challenges of adopting digitalisation and automation in the construction industry to include low readiness among the construction workforce due to their comfortability with traditional construction methods, low level of knowledge about the technologies, and inability to keep up with technological changes. These reports show that readiness is a key factor in adopting digital technologies in construction and needs to be addressed to increase their adoption in the construction industry.

Varying levels of receptiveness

The participants observed differences in technology adoption in the construction industry due to various factors such as the diversity of workforce age groups and the size of construction organisations. **P3** expressed that, *"Early adopters are those in offices, senior managers, and consultants such as myself; the average age of an on-site construction worker is over 50, and it may take time to integrate any AI into their working lives."* According to **P8,** *"Younger professionals and larger firms are typically more open to innovation, while smaller companies and older workers may show resistance."* These findings show that the age group of the construction workforce and the size of construction organisations are significant in adopting digital health and safety methods, as younger workers and larger firms are more open to and willing to adopt digital technologies than older workers and small-sized firms. This result is consistent with the findings of Sepasgozar *et al*. (2018), who found that age, company size, and organisational culture significantly influence the adoption of technology in the construction industry.

Interestingly, one participant noted that the UK might be more progressive in adopting new technologies due to economic pressures. According to **P7**, *"I would say that the UK is probably quite progressive because the margins on projects tend to be so tight, and any competitive advantage that can be gained or that might help in that regard is going to be viewed as a positive thing."* This finding indicates that the receptivity of digital technologies among the construction workforce and organisations can be improved when they are perceived as tools to gain a competitive advantage over their rivals. This perspective aligns with the findings from Shibeika and Harty (2015), who noted that economic factors and the need for competitive advantage can drive the adoption of innovation in construction.

Factors that Contribute to the Slow Adoption of Digital Technologies for Health and Safety Management

Four themes emerged from the thematic analysis of the factors contributing to DT's slow adoption in H&S management in the UK's construction industry. These themes are (1) Reliability of the technologies, (2) High implementation costs, (3) Data privacy and security, and (4) Human oversight.

Reliability of the technologies

The study's findings show that construction stakeholders have an evident skepticism about digital technologies, especially regarding the reliability of AI. For instance, **P1** expressed that *"the reluctance to use AI-driven approaches is due to concerns about the validity of results."* This finding indicates that although digital technologies in construction H&S management benefit the construction workforce, their lack of trust in the reliability of the technologies can impede their adoption by construction stakeholders. This finding aligns with Rampini *et al*. (2022), who found that construction professionals often express skepticism about the reliability of AI-generated outputs in construction management processes**.**

Another respondent, **P9** stated that, *"different systems and technology devices from various manufacturers may not integrate seamlessly, causing data inconsistencies or compatibility issues"*. This finding validates the initial result about the concern bordering on the reliability of digital technologies, which may stem from the previous experiences of the construction workforce with technology devices not integrating seamlessly, resulting in inconsistencies in data and compatibility issues. This finding is supported by Li *et al.* (2019), who reported interoperability challenges as a significant barrier to adopting digital technologies in the construction industry. Additionally, **P15** stated that "digital systems are prone to bugs, glitches, and hardware failures that reduce their dependability, just like any other technology." Also, P18 stated, "*The connectivity on construction sites is unpredictable, especially in remote locations or below-ground works. When we cannot rely on consistent internet access, digital tools become a liability rather than an asset. We need systems that work 100% of the time, not just when conditions are perfect."* These views indicate that systems failure and unreliability issues make it difficult for the construction workforce to accept and adopt digital technologies to manage construction health and safety. These findings are consistent with those of Maskuriy *et al*. (2019), who identified technical issues and system failures as critical challenges in the implementation of digital technologies in construction projects.

High implementation costs

The cost of implementing new technologies was identified as a significant barrier to adopting digital technologies in H&S management. For instance, **P2** stated that *"the adoption of digital technologies depends on costs"*. Another participant, **P5,** elaborated on the budgetary constraints, noting that *"implementation might be more likely if it was offered to you for free or cheap, like at a lower price, and the clients are happy to pay the price."* **P8** corroborated this by further expressing that *"the high implementation costs make it difficult for construction companies to adopt digital technologies eagerly."* **P20** also indicated that, *"The upfront costs of implementing digital safety systems across multiple sites and training everyone to use them properly are prohibitive. We are already operating on thin margins. Unless these technologies can demonstrate clear ROI regarding reduced incidents and insurance premiums, it is hard to justify the investment when traditional paper-based systems still work."*

These findings indicate that despite the benefits that might be derived from adopting digital technologies in health and safety, the high cost of implementing them across several construction sites may impede their adoption by the construction workforce. These findings align with several studies on the cost of implementation as a significant barrier to DT adoption in H&S management. For instance, Oke *et al*. (2018) reported that the high cost of implementation and training employees discourages construction companies from adopting DT. Sepasgozar and Davis (2018) also noted that financial constraints often hinder technology adoption in the construction industry. Oesterreich and Teuteberg (2016) further identified high investment costs as a significant challenge in the construction industry's digital transformation. At the same time, Ikuabe *et al*. (2020) reported that financial barriers are the major obstacles the construction sector faces when adopting DT.

Data privacy and security

Concerns about data privacy and security were prominent among the participants interviewed. For instance, **P11** succinctly mentioned that *"privacy, in general, is an issue; workers feel a way about having these technologies monitoring them when they work; they do not just want it, it is like opening yourself up for investigation."* Another participant **P4** further reported the ambiguity surrounding the General Data Protection Regulation (GDPR) compliance, stating that *"there are increasingly stringent and sometimes ambiguous data protection regulations within the GDPR, which require careful handling of personal and sensitive information, adding complexity to data management."* **P10** also expressed the view that *"construction sites may have inadequate physical security measures to protect on-site digital tech devices and data storage systems"*. **P14** further emphasized that, *"there is a need for thorough testing of these digital technologies before implementing them, particularly when dealing with sensitive data, to prevent security breaches."*

These findings indicate that data privacy and security are paramount to construction stakeholders when considering the adoption of digital technologies. Construction workers, in particular, need to be orientated and trained on using these technologies while being assured of their privacy and the need for and role of the technologies on construction sites. These findings align with the findings of Chung *et al*. (2009), who reported that construction workers often fear privacy invasion when new monitoring technologies are introduced. These findings are also re-echoed by Saah *et al*. (2023), who emphasised the importance of rigorous testing and security protocols for digital technologies in construction.

Human oversight

Some construction companies are concerned about their job roles being taken over by digital technologies. For instance, **P13** said, *"I think the only risk is potential job loss in terms of people who are working because digital technologies are getting so advanced now and that if you are just a regular worker, let us say, a cost estimator or cost manager, your job roles can potentially be automated in the future. We are not there yet because it is getting so advanced quickly."* **P7** added that, *"If managers and employees in the construction industry believe their skills are being neglected, they could be less willing to accept new technology."* Additionally, **P17** noted that *"digital tools are introduced without adequate monitoring of their impact on workers' behaviour and productivity. I think we focus more on the technology and not enough on how humans interact with it."*

These findings show that even when digital technologies benefit the construction workforce, their thoughts and concerns about such technologies must be considered and addressed to avoid feeling neglected. For instance, workers should be assured that the technologies will not replace them and will not be under scrutiny. Construction workers should be carried along at all the phases of adoption to avoid the outright rejection of the technologies and other forms of antagonism. This study is in tandem with the findings of Oesterreich and Teuteberg (2016), who reported the concerns of construction workers regarding job displacement and the potential impact of digitalisation on job roles in the construction industry. Zarir (2023) also reported the challenges of implementing DTs in workplaces and their impact on human workers.

Conclusion

This study explored the response of the UK construction industry to adopt digital technologies for H&S management based on the perceptions of UK construction professionals. The research revealed key findings that provide valuable insights into adopting digital technology in health and safety management.

The study reveals notable resistance to implementing new technologies in the construction industry. This resistance stems from various factors, including difficulties getting software approved at client sites and fears about adopting new technologies. The study found a general lack of knowledge and readiness for adopting new technologies among the construction workforce. The gap in understanding and skills is particularly pronounced among on-site workers (who are advanced in age) and smaller companies. The level of receptiveness to digital technologies varies based on workers' age and the size of construction companies. Younger professionals and larger firms tend to be more open to innovation, while smaller companies and older workers may show more resistance. This is a concern as most firms are small, and many workers are not young. The goal should be to enable SMEs to use DT more. Some factors contributed to the slow adoption of digital technologies for construction H&S management. There is scepticism about the reliability of digital systems in construction. This scepticism stems from concerns about the validity of results, integration issues between different systems, and potential technical glitches or failures. The cost of implementing new technologies was identified as a significant barrier to adopting digital technology. Many construction companies find it challenging to justify the high initial investment required for digital technologies. Concerns about data privacy and security were prominent among participants. These include issues related to GDPR compliance, physical protection of digital devices on construction sites, and the need for thorough testing of technologies for handling sensitive data. There are concerns about job displacement, too, due to automation and potential neglect of human skills in favour of technological solutions.

These findings have several implications for the construction industry, policymakers, and technology developers. There is a clear need for more comprehensive education and training programmes to increase construction professionals' knowledge and readiness for digital technologies at all levels. Also, there is a need to involve the construction workforce at all levels of technology adoption to mitigate potential resistance from them. Technology developers should focus on creating more user-friendly, reliable, and cost-effective solutions that address the specific needs and concerns of the construction industry. Policymakers and industry leaders should consider developing strategies to support smaller companies adopting new technologies, potentially through financial incentives or shared resource programs. There is a need for more explicit guidelines and best practices regarding data privacy and security in the context of digital technologies in construction. The industry should work on developing a balanced approach that leverages the benefits of digital technologies while maintaining valuable human skills and oversight.

This study was limited to the perspectives of twenty UK construction professionals and may not be fully representative of the UK and global construction industry. Future research could expand on this study by conducting a larger-scale quantitative survey to validate our findings across a broader sample of the UK construction industry by comparing the UK's response and readiness for adopting digital technology in construction with other countries.

In conclusion, while the UK construction industry shows potential for benefiting from digital technologies in H&S management, significant challenges must be addressed. By focusing on education, addressing concerns about reliability and security, and developing more accessible and cost-effective solutions, the industry can move towards a more technologically integrated and safer environment for future practice.

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