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Enabling technologies of health and safety practices in the fourth industrial revolution: Nigerian construction industry perspective

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Globally, different approaches have been applied to improve workplace safety practices due to the complexities of construction activities that pose different dangers to workers' safety and wellbeing. This study uses Lagos, Nigeria, as a case study and investigates awareness of 4IR technologies in H&S practices among construction professionals in the Nigerian construction industry. A quantitative research approach was developed to retrieve a structured survey questionnaire from construction stakeholders in the study area. Retrieved data was analysed in three stages: data reliability and validity, descriptive statistics, and exploratory factor analysis (EFA). The descriptive analysis findings and the Kruskal–Wallis H test revealed no significant difference in professionals' awareness of 4IR technologies in H&S practices in the construction project delivery in Lagos, Nigeria. The findings of the EFA returned four-factor components of H&S practices enabling technologies in the Era of 4IR as data and robotic technologies, process-based automation, output communication technologies, and wearable hazard detectives' technologies. This study recommends innovative strategies from the professional bodies through academic and professional development (workshops, training, conferences, and seminars) to improve knowledge of 4IR technologies in H&S practices among professionals.

KEYWORDS

construction industry, digitalisation technologies, fourth industrial revolution, health and safety practices, Nigeria

1 Introduction

Health and safety practices are unavoidable aspects of every construction project management involving human participation from diverse life backgrounds and disciplines working together to deliver the project with minimal accidents (Ogundipe et al., 2018a). Health and Safety (H&S) is organised procedures and efforts to decrease the number of accidents and exposure to dangerous situations and toxic substances in the workplace (Lingard and Rowlinson, 2004). Health and safety practices programme is designed to prevent individuals from potential workplace hazards by providing suitable precautions and a safe working environment (Dodo, 2014; Adekunle et al., 2023b). This is because construction project sites' inherent dangers and complexity make accidents inevitable (Smallwood and Haupt, 2007; Masoetsa, Ogunbayo, Aigbavboa and Awuzie, 2022). Muiruri and Mulinge (2014) concurred that the complexities of construction activities pose different problems to workers' safety and wellbeing. Thus, thousands of workplace deaths, fatalities, and injuries are experienced annually across various sectors (Teo et al., 2005; Kotzé and Steyn, 2013; Seiso et al., 2023).

Over the years, different approaches to health and safety have been developed to improve workplace safety practices. A few of these are known as traditional and total safety management (TSM) approaches to health and safety practices, which offer different strategies to improve health and safety practices in the workplace. The traditional approach to safety dwells on organisational management commitment and policies in controlling hazards and using training motivation to improve workers' behaviours (Mitropoulos et al., 2009; Agwu, 2012; Ogunbayo et al., 2022; Akinradewo et al., 2023) stated that the traditional approach to safety is aimed toward safe working behaviours but with less focus on the influence of group work, worker characteristics, and system operation on work behaviours and potential workplace accidents. The comprehensive safety management approach promotes a safe workplace, enhances worker performance and profitability, and provides continuous improvement in gaining a competitive advantage because TSM provides a performance-oriented approach to safety management (Goetsch, 1999; Zhi, Chunming, and Zhang, 2012; Dennis et al., 2015; Ogundipe et al., 2018b; Ogunbayo et al., 2022). The TSM provides a contextual understanding of safety management beyond the general perspective of culture and behaviour based.

The approaches to health and safety management have evolved in the last four industrial revolutions, with dramatic transformations since the inception of industrialisation in the 18th century (Badri, Boudreau-Trudel, and Souissi, 2018). The industrial revolution 1.0 in the 18th century welcomed machinery powered by a local steam generation, solving production problems from the human manual effort (Lekan, Aigbavboa, Babatunde, Olabosipo, and Christiana, 2022). The Era is known as the technological factor age, from 1970 to 1980. Safety management in construction focuses on using machines to solve technical failures and eliminate the possibility of hazards to workers (Bugalia, Maemura and Ozawa, 2019). The 19th century, named Industry 2.0, witnessed the introduction of electricity, which allowed the broad distribution of power from a central facility, making electricity and machinery less prominent and faster (Adekunle et al., 2022; Lekan et al., 2022). The Era is known as the human factors age in 1990, which was considered an essential aspect of safety management with a focus on human technology (Bugalia, Maemura and Ozawa, 2019). Pillay (2014) and Pillay (2015) postulated that behavioural-based and human error management was incorporated from the perspective of sociology, psychology, and industrial relations into the H&S management. The 20th century, named Industry 3.0, introduced powered assembly lines, and with the development of electronics, manufacturing became increasingly automated and focused on performance (Adekunle et al., 2022). This Era of construction welcomes the organisation factors age in 2000 as an essential aspect of safety management (Bugalia, Maemura and Ozawa, 2019). Bugalia, Maemura, and Ozawa (2019) noted the organisation's age-integrated organisational principles of managing human errors and technical failures in the construction industry H&S practices. The emergence of this revolutionary paradigm shift in the Era of 4IR is marked by innovative technologies that integrate the physical, digital, and biological worlds, impacting all disciplines, including the construction industry and economic development (Schranz, Urban, and Gerger, 2021). The fourth industrial revolution (4IR) exemplifies new ways technology is integrated into communities and daily human activities (Davis, 2016). It demonstrated how technology and labour automation replace duties previously performed by humans (Schwab, 2017). Automation provides various opportunities to optimise construction processes and improve productivity through design flexibility and ergonomics for safer machinery (Badri et al., 2018; Lekan et al., 2022). Thus, Min et al. (2019) maintained that 4IR technologies positively impact the construction economy, which allows new concepts of managing OHS events and networks among independent workers and improves professionals responsible for new OHS issues.

Researchers have highlighted enabling technologies for the construction industry in the Era of 4IR. (Amusan, Adewunmi, Ajao & Ogundipe, 2021; Umar, 2021; Lekan et al., 2022). Umar (2021) maintained the application of drones in H&S monitoring to reduce the cost associated with poor safety practices and avoid delays caused by construction accidents. Amusan et al. (2021) posited that implementing information and technologies (AutoCAD, QSCAD, and BIM 360) in the construction process has improved professional practice among the stakeholders in the Nigerian construction industry. However, managing H&S practices in the Nigerian construction industry has continued to be more complex, transitioning from traditional to technology-enabling practices. However, few studies, particularly in Lagos, Nigeria, holistically have looked into the H&S enabling technologies and offered characteristics of H&S enabling technologies to improve H&S practices in the Era of 4IR.

In addressing the problem of health and safety practices in the construction industry in the Era of 4IR, this research seeks to understand the enabling technologies and strategies for health and safety practices in the Era of 4IR. The study will provide understanding and guidance to health and safety practices in the Era of 4IR. This allows construction organisations to ensure the workplace safety of the construction workers through efficient and effective digital-based H&S processes and procedures for the construction industry. However, there is a need to holistically identify enabling H&S technologies tools in the Era of 4IR from a global context and validate them through statistical analysis. Hence, this study investigates awareness of 4IR technologies in H&S practices among construction professionals in the Nigerian construction industry. The study tested for significant differences between respondents' category of professions and awareness of 4IR technologies in H&S practices in the Nigerian construction industry.

Thus, the empirical study findings are expected to assist construction professionals, clients, and developers in integrating the 4IR technologies in H&S practices in the Nigerian construction projects execution.

TABLE 1 Summary of 4IR technologies for H&S practices and their functions.

Technologies	Description/Function	References
Radio Frequency Identification	This consists of tags and readers used wirelessly to detect, warn, and communicate data to ensure that everyone working there is doing so in a secure atmosphere; both people and machinery use this technology	[55, 56, 57, 74, 75]
Building Information Modelling (BIM)	It enhances the integration of building and structural design, procurement, construction, and end-use. The technology is used to identify potential risks that could develop during construction and offer solutions at the pre-planning stage of site safety management. BIM functions as a semi-automatic technology during construction to verify various safety regulations and plans, identifying conflicts to ensure reasonable safety performance is managed	[46, 47, 49, 50, 76, 77]
Artificial intelligence (A.I.)	A computer-based system can replace people in monitoring and controlling the security of personnel, machinery, and structures. The technology accurately maintains and monitors site H&S and works quicker than humans	[31, 32, 78, 79]
Third-dimensional (3D) printing	A system that automates the construction of structures while reducing danger	[41, 49, 48, 60, 77, 80]
Robotics	Automating construction labour reduces danger zones, improves site visibility, and completes tasks that are even challenging for humans—robotics aid in reducing on-site accidents and human injuries	[62, 63, 64, 65, 76, 77]
Sensors	Use centralised real-time information reporting to analyse health monitoring measurements. Sensors alert workers to threats in their zones, lowering the number of fatalities related to construction safety practices	[37, 57, 80, 81, 82]
Ultra-wideband (UWB)	Uses three or more receivers placed in the monitored area to look for anything that can compromise worker safety	[76, 77, 83]
Internet of Things (IoT)	Provision of automated H&S management procedures from the planning stage through construction	[55, 56, 57, 58, 84]
Smart devices	Tools attached to people and plants can detect potential dangers, keep track of their motions, and compute data and sound alerts when they approach risky areas	[50, 76, 77, 78]
Geographical information systems (GIS)	Creates a system that makes it easier to manage health and safety by gathering the geographic distribution of on-site work utilising spatial relations	[41, 45, 49, 60, 85]
Drones	Captures big video data of a building site from the lowest ground level to the most incredible heights, allowing for real-time movement of the works, detection of potential safety issues, and provision of feedback via aural communication. Additionally, this technology is employed to check on the health and safety of people and plants at work	[67, 68, 86, 87]
Virtual reality (V.R.)	It is used as an automated H&S training tool that visualises real-time hazard detection and improves knowledge of safety management	[60, 61, 78, 82]
Four-dimensional computer-aided design (4D CAD)	This technology contains information about the project's activity. At the design stage, a safety management plan is created after the information has been analysed to identify potential risks	[45, 70, 71, 82]
Global navigation satellite system (GNSS)	It enables easy supervision and administration of workplace safety by providing real-time monitoring of data from a broad population collected by geosynchronous satellites	[57, 76, 58, 84, 83]
Global positing systems (GPS)	The positioning device uses wireless to monitor activity and identify collisions. It functions as a robotic building's security protection machinery	[60, 74, 79, 81]

2 Literature review

2.1 Construction digitalisation in the Era of 4IR

Construction 4.0 is derived from the fourth industrial revolution concept, which refers to the German federal government's creation of the fourth industrial revolution (4IR) in the manufacturing sector. The 4IR has brought diverse technologies to aid day-to-day human activities (Davis, 2016). The 4IR allows people and objects to connect to create the factory of the future, which secures the complete digitalisation of the manufacturing innovation that allows the real and virtual worlds to merge using IoT, simulation, and virtualisation (Heynitz and Bremicker, 2016; Daniel, 2020). These are essential technologies and automation replacing tasks previously performed by the human workforce (Schwab, 2017). In recent years, digitalisation has been viewed as a crucial driver of educational innovation (Gillpatrick, 2020). Digitalisation is the conversion of all sorts of information into digital language, including text, sounds, pictures, video, and other data from diverse sources (Machekhina, 2017). Digital technologies could advance the interconnectivity of site meetings and inspection processes for health and safety practices (Smoląg et al., 2015). Madan, Sharma, and Seth (2016) contend that incorporating digital technologies in health and safety practices facilitates the advancement of 4IR in the construction industry.

The major goal of construction operations in the Era of 4IR is to create a digital construction site by installing internet-connected sensors on equipment at each project stage to track progress and use drones and virtual simulations (Oesterreich and Teuteberg, 2016). Construction health and safety practices in the Era of 4IR integrate modern technologies to promote the digitalisation of the construction industry and supply chain, resulting in improved performance (Oesterreich and Teuteberg, 2016; Mahamood and Akinlabi, 2018). Digitalisation in health and safety practices refers to converting images, video, and sound into digital format utilising technologies such as artificial intelligence (A.I.) devices, cameras, scanners, the Internet, and sensors (Bejinaru, 2019). It also involved using electronic platforms for transferring traditional forms of teaching and learning into virtual environments, such as online courses, online webinar training, and health and safety training and practices (Gavish et al., 2015). Daniel (2020) noted that these electronic platforms include communication and online synchronising processes. Salvatore and Stefano (2021) highlighted some enabling technologies that have been developed to carry out workplace duties, such as robotics, artificial intelligence (AI), the Internet of Things (IoT), and nanotechnology. The 4IR technologies simplify all essential components of H&S management training, communication, monitoring, and regulations. As shown in Table 1, it embraces collaborative human-robot teams and safety training using virtual reality, augmented reality, automated inspection, simulation training, and other methods (Nnaji and Karakhan, 2020). Thus, Adekunle et al. (2023a) admitted that the strategies for integrating 4IR technologies in H&S practices require collaboration among stakeholders and government to educate and train small construction stakeholders, clients, and end-users.

2.2 Health and safety enabling technologies in the Era of 4IR

Understanding H&S enabling technologies in the construction industry and how they have been embraced over time is vital to comprehend the digital technologies suitable for health and safety practices in the Era of 4IR. Aghimen et al. (2020) posted that digital technology applications for health and safety help to deliver tangible and intangible services to the construction industry. Aghimien, Oke, and Aigbavboa (2018) identified enabling technologies for effective H&S practices in the Era of 4IR to include augmented reality, big data, building information modelling, construction blockchain digitalisation, drones, internet of things (IoT), radio frequency identification (RFID), cyber-physical systems, robotics, and virtual reality for construction digitalisation. These technologies enable internet sensors to monitor building activities on sites establishment of intelligent construction sites.

2.2.1 Augmented reality

Augmented reality (AR) provides an interactive experience of visualising information, images, and data on a real-time construction site (Chu, Matthews, and Love, 2018; Sidani et al., 2021). Augmented reality (AR) visualises components to be produced and the construction stages for a given construction site, allowing the construction stakeholders to clarify ambiguities about the construction process, enhancing the quality of the construction and avoiding the need for rework. Park, Lee, Kwon, and Wang (2013) stated that the visualisation of 3D models helps resolve conflicts and doubts during construction. The data associated with the 3D models (related to the schedule of expenses, 4D and 5D models) clarify technical requirements specifics of specific materials and equipment and add pertinent information for the construction process (Chalhoub, and Ayer, 2019; Ratajczak, Riedl, and Matt, 2019). Thus, BIM and visualisation technologies like augmented reality enhance health and safety practices in construction project management (Schranz et al., 2021).

2.2.2 Radio frequency identification

The use of Radio Frequency Identification (RFID) in construction enhances the automation of the construction process by supplying effective tracking of equipment and tools, theft prevention, and inventory management (Costin and Teizer, 2015). RFID could help the construction industry move away from reactive maintenance by automatically allowing equipment and machinery to convey performance data through engineers working on construction sites (Sardroud, 2012). Technologies like global posting systems (GPS) and RFID help monitor workplace activities, transfer communication, and detect dangerous regions' reports on impending risks (Zhang, Cao, and Zhao, 2017).

2.2.3 Building information modelling

Building information modelling (BIM) creates and manages information at all stages of a construction project's lifecycle (planning, design, construction, operation, and liquidation) (Moghadam, 2014; Ogunde et al., 2017a). Ogunde et al. (2018) and Farnsworth et al. (2015) argued that BIM must be combined with other technologies, such as cloud computing, to reap its full benefits, enabling the free flow of information within the construction industry. It is projected to deliver fast information for construction professionals using cloud data storage. Fernandes (2013) concurred that BIM, virtual reality, 3D printing, and other technologies are useful at all stages of the construction process, especially for managing health and safety practices. Creating a 3D point cloud through remote sensing and photometry-based methods is necessary to overcome the labour-intensive construction process. Technology like BIM can also improve managing and keeping track of the entire project from the design stage to the closeout stage (Smallwood, Emuze and Allen, 2012). Choi, Ahn, and Seo (2020) maintained that BIM integrates processes that help prevent accidents, increase visibility, make reporting and accountability easier, foster healthier communication, and improve productivity.

2.2.4 Big data technologies

Big data technologies support analytical techniques for occupational health and safety hazard analytics. It is an emerging technology that refers to datasets with many orders of magnitude larger than the standard files transmitted through the Internet (Suthakar et al., 2016). Big data utilising various analytics information (exploratory, descriptive, predictive, and prescriptive) to determine future occurrences. These techniques simplify key factors and emphasize relationships between a safety phenomenon and the data (Landset et al., 2015). Abioye et al. (2021) argued that the Big Data accident prediction platform (B-DAPP) helps construction stakeholders to minimise occupational hazards on construction sites (Abioye et al., 2021). This is because big data technology possesses parallel processing features and the ability to efficiently handle high dimensional, noisy data with nonlinear relationships, which could help in health and safety risks analytics (Abioye et al., 2021). Hence, Dini et al. (2019)

concurred that big data could be generated and acquired through activities such as risk evaluation and assessment, biological monitoring, or worker health surveillance programs (i.e., computational and digital Big Data). Worker health surveillance enables a longitudinal, dynamic follow-up of the working population.

2.2.5 Internet of things

The Internet of Things (IoT) has become a critical component of societal progress and technological development in the modern world. IoTs are cyber-physical systems that connect and collaborate with humans in real time via Internet services (Dong, Chang, Wang, and Yan, 2017). IoTs are often described as a network linking things that connect objects (Dong et al., 2017). It uses a pre-established protocol on information sensor teeth like sensors, 2-dimensional quotes, and radio frequency identification technology (RFID). IoT facilitates more frequent, quicker, and easier connectivity between people and devices (Magrassi and Berg, 2009). Ashton (2009) IoTs are useful for managing supplies, cutting waste, saving costs, and detecting when equipment needs to be serviced or replaced to prevent occupation hazards. The construction industry has adopted innovations like Internet-connected pieces and mobile phones (Wang et al., 2019). Therefore, IoTs could be used in the construction industry to complete self-diagnosis, self-configuration, and self-optimization to improve service delivery (Wang et al., 2019).

2.2.6 Virtual reality technologies

Virtual reality (VR) creates a wholly unreal environment or fiction that helps users gain insights into the real world. It functions through simulation, created in 3D deception of their environment (Li et al., 2018). Due to the substantial risk of accidents in the construction industry, VR has been developed to increase safety training on health and safety practices in the construction industry. For instance, a virtual platform has been established to enable university students to receive safety information by scanning QR codes using mobile devices and simulation-based training (Wang et al., 2018).

2.2.7 Robotic technologies

Robotic technologies have several uses in the construction industry. They are developed to automate existing machinery for the construction process. Adopting robotic technologies in the construction industry reduces human involvement (Aghimien et al., 2019). Robotic technologies could be used for physical construction activities like prefabricating building interior finishing and bricklaying. Construction robots like bulldozers, dump trucks, backhoes, and automatic control shield machines can be used on-site or off-site construction (Yahya et al., 2019). Using robotics in the manufacturing and construction industries ensures fewer injuries (Tambi, Kolhe, and Saharkar, 2014). However, Cai et al. (2018) posit that the decision to use robotics and automation technologies in a construction project must be implemented from the early design stage.

2.2.8 Drones technologies

Drones are crewless aerial vehicles that do not need or rely on a human onboard operator for a flight, either autonomously or remotely operated (Golizadeh et al., 2019). Drones could be used to survey large construction sites. Crewless aerial vehicles make drones easy to access extensive, difficult-to-reach, complex, or high-rise facilities in construction sites (Erenoglu, Akcay, and Erenoglu, 2017). It produces aerial photography data, map information, and photos for various purposes, including land surveying, building inspections, providing visual materials to clients and staff, tracking the development of construction projects, maintaining security, mapping, and health and safety monitoring (Herlitschka and Valtiner, 2017). The future development of intelligent solutions automation and the deployment of crewless aerial vehicles could enable construction stakeholders to manage projects.

2.2.9 Cybersecurity technologies

Cybersecurity tools are policies and procedures that safeguard assets, including computers, infrastructures, humans, and data (Roldán-Molina et al., 2017). Cybersecurity awareness and investment in the construction industry will promote high-level security that could leave this industry susceptible and particularly attractive to hackers (Watson, 2019). The number of stakeholders and the extensive supply chains primarily made up of small companies with scant resources allocated to information technology increases the industry's vulnerability to cyber-attacks. Consequently, concentration is a crucial factor to be considered for the construction industry's Smooth transition to the digitalisation of the architectural, engineering, and construction (AEC) industry into cybersecurity (Parn and Edwards, 2019). Turk et al. (2022) noted that digital technology had been integrated into the built environment design and management, making it increasingly exposed to cybersecurity risks. Cyber risks are detrimental to the construction industry's success. They can be minimised by developing cyber security processes, providing cyber security training courses, updating and upgrading programs regularly, and fostering a cyber security climate (Caponi and Belmont, 2015). Nonetheless, cybersecurity protects the overlapping process and organisational boundaries at the design phase, the exposed shared design information, and the vulnerability of control information of the environment, especially in sensitive infrastructural development (Turk et al., 2022).

2.3 Challenges of 4IR technologies integration in construction health and safety practices

Several challenges are attributed to applying 4IR technological tools in the context of construction safety in developing countries. Umar (2021) posited that enabling 4IR technologies for managing construction health and safety practices offers several benefits, but some factors must be considered before integrating them into construction processes. Wang et al. (2016) maintained that privacy liability, legislation, all regulations, and risks for construction-related businesses are factors construction organisations must consider before integrating. Gheisari and Esmaeili (2019) attributed the problem of using 4IR technologies in the construction industry to safety concerns, technical challenges, a requirement for a certified operator, extensive training requirements, and liability and legal concerns. Umar (2021)

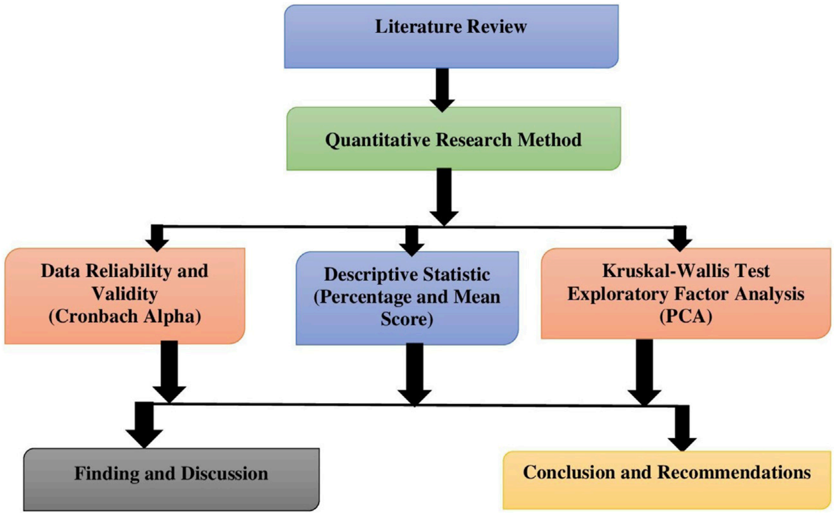

FIGURE 1
Research flowchart.

further suggests understanding the problem associated with the general application, safety-related application, technical requirements and features, and barriers using 4IR-enabling technologies for safety-related operations. Malomane, Musonda, and Okoro (2022) postulated that expensive technologies, inadequate relevant skills, the unavailability of training capacities, a lack of adequate, and negative perceptions such as fear of job loss by construction professionals challenged the implementation of 4IR technologies in the construction industry.

The regulations and laws supporting health and safety practices are major factors relevant to integrating 4IR technologies in the construction industry in developing countries. This is because health and safety regulations, policies, or laws in developing countries' construction industries are generally weak and poor (Umar, Egbu, Wamuziri & Honnurvali, 2018; Boadu et al., 2021; Ezeokoli et al., 2016). Boadu, Wang, and Sunindijo (2021) posited the non-availability of comprehensive occupational health and safety (OHS) policies or laws in the Ghanaian construction industry. This is also evident in the lack of innovative drive on OHS enforcement strategies and ineffective implementation of OHS regulations, standards, and policies (Boadu et al., 2021). Umar, Egbu, Wamuziri, and Honnurvali (2018) contend that Oman's current regulations for occupational health and safety comprise four chapters: precautionary against occupational hazards, workers' wearable devices specification, medical care, and OSH management and enforcement by ministry inspectorates, without provisions use of 4IR technological tools. It is pertinent to note that the Gulf Cooperation Council construction (GCC) region in which Oman is a member has a stable economy, and investment in safety-related things is not an issue as compared with the Nigerian and other developing countries' construction industry (Umar, 2021; Ezeokoli et al., 2016. Ezeokoli et al. (2016) posited that the Nigerian construction industry does not have construction occupational safety and health regulations or laws supporting the integration of 4IR technological tools. Further, the study of Adeyemo and Smallwood (2017) asserted that compared with Occupational safety and health regulations in Oman and other developed countries, safety-related basic regulations are ineffective when it comes to developing countries. Several efforts were made to upgrade health and safety practices to digitalization through legislation for the construction industry in developing countries, including Nigeria, yet construction firms still record poor H&S practices (Adeyemo and Smallwood, 2017; Malomane et al., 2022).

3 Research methods

This study adopted quantitative research methods (See Figure 1) while exploring the extant literature review to understand and identify 4IR enabling technologies per the study's objectives. Gough et al. (2017) and Martins et al. (2019) described literature review as either a qualitative or quantitative means of selecting, identifying, and critically appraising research questions to formulate answers. Paré and Kitsiou (2017) posited that the extant literature review provides an understanding of prior knowledge in the field of research. It involves a collection of relevant books, peer-reviewed articles, conference papers, and dissertations (Nathaniel, 2022). An extant literature review conducted in this study allows the researcher to understand 4IR technologies in H&S practices in the construction industry using online academic databases, including Google Scholar, Scopus, Science Direct, ResearchGate, and Web of Science. Likewise, Apuke et al. (2017) described quantitative research methods as explaining an issue or phenomenon in numerical data or quantifying and analysing variables. The quantitative research method takes a deducible way to connect theory and research (Umar, 2020). Thus quantitative approach was used for this study because it enables the generalisation of research findings based on data collection and analysis in the study area (Eyisi, 2016). This is also because the quantitative research method is well-appropriate for establishing relationships, testing hypotheses, and determining the opinions of a large population compared with the qualitative research method (Eyisi, 2016). It can also help provide insights into the significance of relationships, differences, or trends through the use of statistical tools and tests to analyze data.

The study identified 16th enabling technologies for H&S practices via an extant literature review developed into a structured questionnaire before sampling the opinion of the stakeholders in the built environment (architects, civil engineers, construction managers, mechanical engineers, and quantity surveyors), among others. The selection of the construction stakeholders in Lagos, Nigeria, was based on their experience in construction projects in the Nigerian construction industry. Lagos state is a commercial hub with several construction activities, including the Dangote petroleum refinery, Eko Atlantic City, Lekki free trade zone, Lekki Deep Sea Port and Lagos Island International Airport and other real estate buildings (Osotimehin et al., 2012; Ogunde, 2017b; Ogundipe et al., 2018c). The structured survey questionnaire was designed on a Likert scale based on the research objective. Respondents were asked to indicate their level of agreement with the identified H&S enabling technologies in the Nigerian construction industry using 5 = Very High (VH), 4 = High (H), 3 = Average (A), 2 = Low (L), 1 = Very Low (VL). Through the purposive quota sampling technique, two hundred (200) questionnaires were administered, and one hundred and eighty-seven (187) responses were retrieved for the analysis, representing 94% of the total questionnaires administered.

In determining the sample size from the targeted population (professionals within the built environment in Lagos, Nigeria). The sample size of 176 was calculated using Yamane's (1967) equation from the targeted 20,422 population of professionals within the built environment in Lagos, Nigeria, which set the minimum sample size for this study. Thus, Yamane's (1967) equation, as cited by Bell and Bryman (2007), was used to calculate the sample size that could represent the total population (20,422) of professionals within the built environment in Lagos, Nigeria. Yamane's (1967) equation provides a simplified formula to calculate sample sizes, allowing inferences and conclusions drawn from surveys to be applied to the complete population from which the sample was drawn. Hence, Eq. 1, 2 was used to calculate the sample size for this research concerning the population under study.

$$n = \mathrm{N} \big/ \left[1 + \mathrm{N}(\mathrm{e})^2\right] \tag{1}$$

Where n is the random sample size, N is the population size, and e is the level of precision. In Yamane's Equation (Yamane's, 1967), the level of precision is set at a 95% significant level and is equivalent to $p = 0.05$, which was adopted for this Equation in this study.

$$n = 20422 \big/ 1 + (20422)\,(0.075)2 = 176 \tag{2}$$

According to Eq. 2, the sample size required for this study was 176 respondents. However, the actual number of respondents used for this study was 187. The 187 responses used for this study agree with the recommendations (Pallant, 2013; Pallant, 2016; Kothari, 2008). Descriptive and exploratory factor analysis (percentage, frequency, and standard deviation) were performed on the retrieved data using IBM SPSS Statistics version 26. The non-parametric test uses the Kruskal–Wallis H to analyse groups' variance to compare the mean scores on the continuous variables in line with the professional respondents (Pallant, 2016; Ade-Ojo and Awodele, 2020; Ejidike, Mewomo and Anugwo, 2022). The study data adequacy for exploratory factor analysis (EFA) was determined through Kaiser–Meyer–Olkin (KMO) and Bartlett's sphericity test. EFA reduces larger datasets into small components by establishing their level of relationship. Also, Cronbach's alpha test helps to determine data reliability and the interrelatedness of the variables in each component (Pallant, 2013). Tavakol and Dennick (2011) posited that Cronbach's alpha test explores the scale reliability of data through their internal consistency. The reliability of the data collection instrument returned 0.839 > 0.6 value of the coefficient of Cronbach's alpha scale recommended by (Eiselen, Uys and Potgieter, 2007). This justifies the reliability of the data collection instrument and the responses obtained from the field survey. The results of the analysis were presented in tables.

4 Findings and discussion

4.1 Respondents' demographic characteristics

Table 2 below indicates the demographic characteristics of the respondents based on their years of experience, which shows that 7.5% have 1–2 years of experience, 22.5% have 3–5 years of experience, 20.9% have 6–10 years of working experience, 21.9% have between 11–15 years of working experience, 17.6% that have 16–20 years of working experience, 6.4% have between 21%–25% years of working experience, while only 3.2% have above 25 years of working experience in the construction industry. In addition, regarding the respondents' professional designation, 16.6% are Quantity Surveyors, 2.7% are Mechanical Engineers, 15.5% are Architects, and 22.5% are Civil Engineers. In addition, 24.1% are Builders, 9.6% are Construction Managers, 4.8% are Electrical Engineers, and 4.3% are Town Planners. The respondents with the highest academic qualification are doctorate holders with 4.8%, while 8%, 29.9%, 40.1%, and 8% of the respondents have a master's degree, bachelor's degree, Higher National Diploma, and National Diploma, respectively. Also, 52.9% of the respondents work in contracting firms, 25.1% in government ministries, 13.9% in consulting firms, and 8.6% in professional institutions. The respondent's involvement in construction projects in the last 5 years shows that 4.8% of the respondents have been involved in 4–6 projects, 10.2% are engaged in 7–9 projects, 40.1% were engaged in 10–12 projects, 31.6% were involved in 13–15 projects, while 13.4% of the respondents have been involved in over 15 projects. The respondents' demographic characteristics show prior knowledge and experiences in construction project delivery. However, construction stakeholders will require innovative strategies through academic and professional development (workshops, training, conferences, and seminars) to improve their knowledge of 4IR technologies in H&S practices. This result is consistent with Adekunle et al. (2023), affirming collaboration among stakeholders and government to educate and train small construction stakeholders, clients, and end-users on 4IR technologies to improve H&S practices. In addition to the result of this study, Nnaji and Karakhan (2020) admitted that stakeholders must embrace collaborative human-robot teams

TABLE 2 Demographic characteristics of the respondents.

Background information of respondent	Frequency (*n* = 187)	Percentage (%)
Years of experience		
25 years and above	6	3.2
21–25 years	12	6.4
16–20 years	33	17.6
11–15 years	41	21.9
6–10 years	39	20.9
3–5 years	42	22.5
1–2 years	14	7.5
0–1 years	0	0
Total	187	100
Respondents' Professional Designation		
Quantity Surveyors	31	16.6
Mechanical Engineers	5	2.7
Architects	29	15.5
Civil Engineers	42	22.5
Builders	45	24.1
Construction Managers	18	9.6
Electrical Engineers	9	4.8
Town Planners	8	4.3
Total	187	100
Respondent Academic qualification		
Doctorate	9	4.8
Master's degree	15	8
Bachelor's degree	56	29.9
Higher National Diploma	75	40.1
National Diploma	32	17.1
Total	187	100
Respondents Operation Area		
Contracting firms	99	52.9
Government ministries	47	25.1
Consulting firms	26	13.9
Professional institutions	15	8.1
Total	187	100
Respondents Involvement in Construction Projects in the Last 5 Years		
Over 15 projects	25	13.4
13–15 projects	59	31.6
10–12 projects	75	40.1
7–9 projects	19	10.2

(Continued on following page)

TABLE 2 (*Continued*) Demographic characteristics of the respondents.

Background information of respondent	Frequency (*n* = 187)	Percentage (%)
4–6 projects	9	4.8
Total	187	100

TABLE 3 4IR technologies for H&S practices in the 4IR Era.

Enabling technologies	Mean	Std. D	Rank	Chi-square	Asymp. Sig
Augmented reality	4.09	0.812	1	4.484	0.723
Robotics and automation	4.05	0.914	2	6.945	0.435
Sensor-based technologies	4.05	0.914	2	6.739	0.457
Drones	3.97	0.891	4	8.704	0.275
Big data	3.96	0.841	5	4.970	0.664
Unmanned aerial vehicle (UAV)	3.95	0.869	6	7.459	0.383
Internet of Things (IoT)	3.94	0.784	7	7.275	0.401
Photogrammetry	3.93	0.886	8	5.761	0.568
Geographical information system (GIS)	3.88	0.937	9	4.157	0.762
Virtual reality	3.87	0.889	10	11.665	0.112
Radiofrequency identification (RFID)	3.87	0.841	10	8.629	0.280
Laser scanning	3.86	0.951	12	5.197	0.636
Wearable technology and smart PPE	3.73	1.060	13	7.342	0.394
Building information modelling (BIM)	3.61	1.054	14	10.249	0.175
4D computer-aided design (4D CAD)	3.55	1.146	15	2.942	0.890
3D printing	3.48	1.049	16	8.442	0.295

and safety training using virtual reality, augmented reality, automated inspection, simulation training, and other methods.

Table 3 revealed the descriptive analysis of the professional awareness of 4IR technologies in H&S practices within the construction industry. The opinions of respondents were retrieved in line with their agreement with the survey questions using the following: 5 = Very High (VH), 4 = High (H), 3 = Average (A), 2 = Low (L), 1 = Very Low (VL). Augmented reality ranked first with MS = 4.09; Std. D = 0.812, robotics and automation with MS = 4.05; Std. D = 0.914 and sensor-based technologies with MS = 4.05; Std. D = 0.914 ranked second. The enabling technologies tools ranked third—sixth are drones with MS = 3.97; Std. D = 0.891, big data with MS = 3.96; Std. D = 0.841 and unmanned aerial vehicle (UAV) with MS = 3.95; Std. D = 0.869. Internet of Things (IoT) ranked seventh with MS = 3.94; Std. D = 0.784, the eighth-ranked digitalisation tool is photogrammetry with MS = 3.93; Std. D = 0.886, followed by the geographical information system (GIS) with MS = 3.88; Std. D = 0.937 and virtual reality with MS = 3.87; Std. D = 0.889 ranked ninth and 10th, respectively. In addition, radiofrequency identification (RFID) with MS = 3.87; Std. D = 0.841 ranked 11th, laser scanning with MS = 3.86; Std. D = 0.951 ranked 12th, while wearable technology and smart PPE with MS = 3.73; Std. D = 1.060 ranked 13th. The last three digitalisation tools ranked from the 14th to 16th are building information modelling (BIM) with MS = 3.61; Std. D = 1.054, 4D computer-aided design (4D CAD) with MS = 3.55; Std. D = 1.146 and 3D printing with MS = 3.38; Std. D = 1.049.

The study tests the significant difference between respondents' category of professions and awareness of 4IR technologies in H&S practices in the Nigerian construction industry. The Kruskal–Wallis H findings of the sixteen identified 4IR technologies in H&S practices in the Nigerian construction industry, the chi-square (x2) value ranges (2.2942–11.665), with a *p*-value of (0.112–0.890). This implies no significance in the professional awareness of 4IR technologies in H&S practices in the Nigerian construction industry. The range of *p*-value of (0.112–0.890), greater than 0.05, shows no significant difference in perceptions of respondents' awareness of 4IR technologies in H&S practices in the Nigerian construction industry. The study findings collaborate with Osotimehin et al. (2012), Ogunde (2017b), and Ogundipe et al. (2018c), who claim that the nature of construction activities in Lagos, Nigeria, requires using 4IR technologies to improve H&S practices in project delivery. These findings imply that the agreement among the professionals' perception shows they are fully aware of 4IR technologies in H&S practices in Lagos, Nigeria, which can further impact construction firms in other states of Nigeria. Similarly, the study findings supported by Schranz, Urban, and Gerger (2021) claimed that a revolutionary

TABLE 4 KMO and Bartlett's test of 4IR technologies for H&S practices in the 4IR Era.

KMO and Bartlett's test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.811
Bartlett's Test of Sphericity	Approx. Chi-Square	1,690.717
	Df	120
	Sig	0.000

TABLE 5 Communalities Table.

Health and safety practices enabling technologies in 4IR	Initial	Extraction
Augmented reality	1.000	0.718
Big data	1.000	0.672
Drones	1.000	0.602
Internet of Things (IoT)	1.000	0.693
Robotics and automation	1.000	0.724
Virtual reality	1.000	0.665
Building information modelling (BIM)	1.000	0.845
3D printing	1.000	0.785
4D computer-aided design (4D CAD)	1.000	0.661
Unmanned aerial vehicle (UAV)	1.000	0.829
Laser scanning	1.000	0.770
Geographical information system (GIS)	1.000	0.684
Photogrammetry	1.000	0.633
Sensor-based technologies	1.000	0.567
Radiofrequency identification (RFID)	1.000	0.619
Wearable technology and smart PPE	1.000	0.539
Extraction Method: Principal Component Analysis		

paradigm in the traditional approach has increased construction stakeholders' knowledge of 4IR technologies to improve H&S practices in project delivery in the construction industry.

4.2 Exploratory factor analysis result

The exploratory factor analysis of the study investigates awareness of 4IR technologies in H&S practices among construction professionals in the Nigerian construction industry using the IBM SPSS statistics version 26. The exploratory factors analysis used principal component analysis to check the data suitability for factor analysis. Table 4 shows the KMO test returned a 0.811 value for sample adequacy; this value is satisfactory because it falls within the 0.6–1.0 recommended value for EFA (Hair et al., 2006; Tabachnick and Fidell 2007; Eiselen et al., 2007). Table 4 returned a 0.000 significance value, indicating the acceptance of the data for factor analysis. This value aligns with George and Mallery (2003) recommendation that a significant value <0.05 represents that the data obtained does not generate an identity matrix and is acceptable for factor analysis. Table 3 also shows a correlation coefficient >0.3, which supports the KMO and Bartlett's test for the factorability of the data sets.

Table 5 reveals the communalities on awareness of 4IR technologies in H&S practices among construction professionals in the Nigerian construction industry. The 16th listed 4IR technologies for H&S practice with extraction values above 0.3 are presented in Table 5, which means the listed 4IR technologies fit well in their components without any signs of variance. Thus, the factor grouping can be relied upon because none of the variables has a low extraction value.

Table 6 shows the analysis of the awareness of 4IR technologies in H&S practices among construction professionals in the Nigerian construction industry and their respective eigenvalues using latent root or Kaiser's criterion in retaining components with 1.0 eigenvalues. Hence, four components with eigenvalues greater than 1.0 were identified with 5.803, 2.563, 1.432, and 1.208, which explains 36.266%, 16.018%, 8.950%, and 7.550%. These components

TABLE 6 Total variance explained.

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings[a]
	Total	% of Var	Cumu. %	Total	% of Var	Cumu. %	Total
1	5.803	36.266	36.266	5.803	36.266	36.266	4.880
2	2.563	16.018	52.285	2.563	16.018	52.285	2.504
3	1.432	8.950	61.235	1.432	8.950	61.235	4.222
4	1.208	7.550	68.785	1.208	7.550	68.785	2.018
5	0.914	5.711	74.496				
6	0.682	4.260	78.756				
7	0.580	3.627	82.383				
8	0.545	3.405	85.789				
9	0.524	3.273	89.061				
10	0.377	2.354	91.415				
11	0.365	2.282	93.697				
12	0.299	1.871	95.568				
13	0.250	1.563	97.132				
14	0.196	1.227	98.358				
15	0.174	1.089	99.448				
16	0.088	0.552	100.000				

Extraction Method: Principal Component Analysis. a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance

explain a cumulative percentage of the variance of 68.785 of the variables.

Figure 2 shows the scree plot for the data analysed, highlighting the eigenvalue for the 16th variable of 4IR technologies for H&S practices in construction project delivery. The steep slope scree plot graph and a break after the fourth factor using the oblimin rotation method because the 16th variables correlated to a certain degree. The steep slope shows the significant factors, while the gradual trailing shows the rest of the factors with an eigenvalue lower than 1. The four essential components of factors positioned on the steep slope were retained.

4.3 Exploratory factor component report

Table 7 shows the pattern matrix of the 16th identified 4IR technologies for H&S practices in the construction project delivery factored into four components. The interpretation is based on the observed inherent relationship between the variables of 4IR technologies for H&S practices in the construction project delivery in each component before assigning a familiar name to them. Hence, factor 1 is named "data and robotic technologies," factor 2 is "process-based automation technologies", factor 3 is "output communication technologies', and factor 4 is "hazard detectives wearable."

4.3.1 Component one: data and robotic technologies

The first component gathered six variables into the component with 36.266% cumulative variance. They are the Internet of Things (IoT) (85%), virtual reality (83%), robotics and automation (78%), big data (77%), drones (74%), and augmented reality (65%). The H&S practices enabling technologies gathered in this component are named data and robotic tools, which allow construction organisations to keep records of health and safety incidents and deploy robotic tools and virtual reality to monitor real-life site activities. These align with the findings of research by Aghimen et al. (2019), which informed about the different applications of digital technology tools in delivering tangible and intangible services, health, and safety within the construction industry. Additionally, the study results further confirm Aghimien et al. (2020) and Aghimien et al. (2018) assertion that technologies used for effective H&S practices in the 4IR include augmented reality, big data, the Internet of Things (IoT), virtual reality, and robotics. Digitalisation tools primarily allow visualising information, imagery, and data on a real-time construction site (Chu et al., 2018; Sidani, 2021). Hence, in supporting the study's findings, Yahya (2019); Tambi et al. (2014) admitted that construction equipment like bulldozers, dump trucks, backhoes, and automatic control shield machines can be digitalised for on-site or off-site construction.

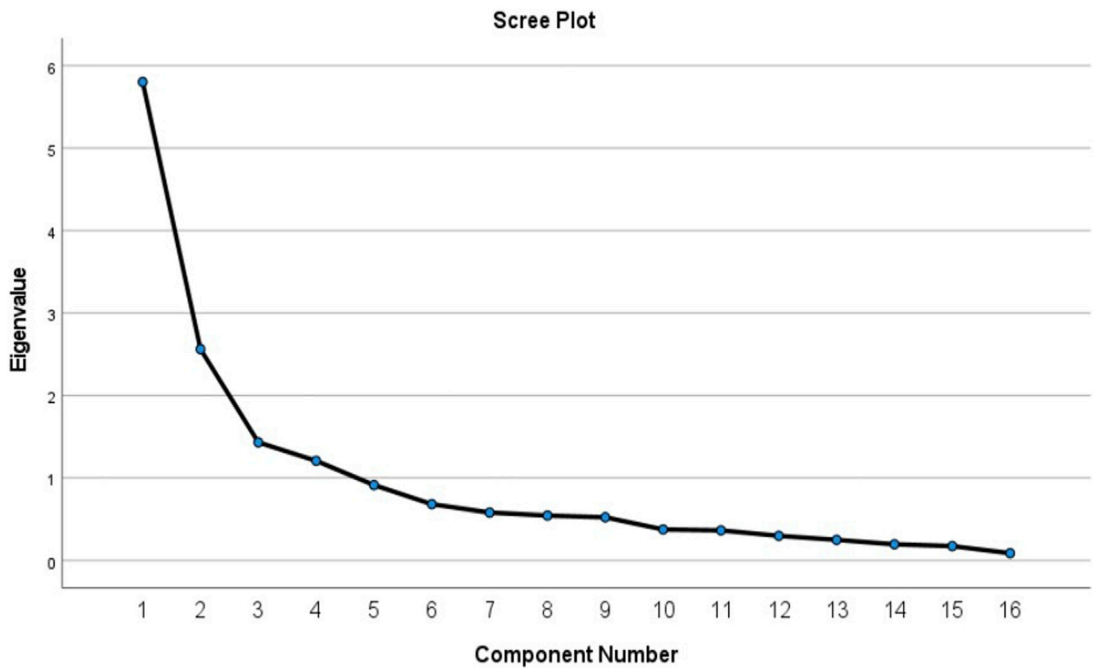

FIGURE 2
Scree plot of health and safety practices enabling technologies in the 4IR Era.

TABLE 7 Pattern matrix[a].

Digitalisation tools	Component			
	1	2	3	4
Internet of Things (IoT)	0.845			
Virtual reality	0.828			
Robotics and automation	0.775			
Big data	0.773			
Drones	0.738			
Augmented reality	0.648			
Building information modelling (BIM)		0.898		
3D printing		0.886		
4D computer-aided design (4D CAD)		0.822		
Laser scanning			0.875	
Unmanned aerial vehicle (UAV)			0.868	
Geographical information system (GIS)			0.772	
Photogrammetry			0.683	
Wearable technology and smart PPE				0.742
Radiofrequency identification (RFID)				0.562
Sensor-based technologies				0.508

Extraction Method: Principal Component Analysis. Rotation Method: Oblimin with Kaiser Normalization. a. Rotation converged in 6 iterations

TABLE 8 Component correlation matrix and reliability of components.

Component	1	2	3	4	Cronbach's alpha coefficient
1 Data and robotic tools	1.00	0.16	0.45	0.24	0.883
2 Process-based automation tools	0.16	1.00	0.06	0.01	0.837
3 Output communication tools	0.45	0.06	1.00	0.18	0.862
4 Hazard detective's wearable	0.24	0.07	0.19	1.00	0.765

4.3.2 Component two: process-based automation

The three variables loaded into the second component are building information modelling (BIM) (90%), 3D printing (87%), and 4D computer-aided design (4D CAD) (82%). The component gathered a cumulative percentage of 16.018 of the variances. These H&S enabling technologies are named process-based automation, which aids the construction stakeholders in making better decisions and managing the construction process. According to the results of this study, BIM improves construction processes by managing and keeping track of the entire project from the design stage to the closeout stage, which is consistent with the findings of (Sardroud, 2012; Smallwood et al., 2012; Fernandes, 2013; Costin and Teizer, 2015; Ratajczak et al., 2019). BIM integrates processes that help prevent accidents, increase visibility, make reporting and accountability easier, foster healthier communication, and improve productivity. The findings also align with Choi et al. (2020), Zhang et al. (2017), Moghadam (2014), Farnsworth et al. (2015), BIM creates and collects information at all stages of a construction project (planning, design, construction, operation, and liquidation). Likewise, as informed by the study findings in collaboration with Park et al. (2013) and Ratajczak et al. (2019), process-based automation technology tools such as 3D printing help visualisation resolve conflicts and doubts during construction. Moreover, the data associated with the 3D models (related to the schedule of expenses, 4D and 5D models) clarifies technical requirements for specific materials and equipment and adds pertinent information for the construction process.

4.3.3 Component three: output communication technologies

The third component had four variables loaded into the component. They are laser scanning (88%), unmanned aerial vehicles (UAV) (87%), geographical information systems (GIS) (77%), and photogrammetry (68%). The component gathered a cumulative percentage of 8.950 of the variance. The H&S enabling technologies loaded in this component are named output communication tools. In the area of communication, the study findings show that 4IR technologies such as laser scanning, unmanned aerial vehicles (UAV), geographical information systems (GIS), and photogrammetry improve digitalisation health and safety practices in the construction industry (Zhou et al., 2012; Hanus and Harris, 2013; Tatum and Liu, 2017; Fenais et al., 2019).

4.3.4 Component four: hazards detective wearables

The three variables loaded into the fourth component are wearable technology and smart PPE (74%), radiofrequency identification (RFID) (74%), and sensor-based technologies (74%). The component gathered a cumulative percentage of 7.550 of the variances. The study findings show that hazard detective wearables improve the construction industry's health and safety practices. The result validates findings, which show that wearable technology and smart PPE, radiofrequency identification (RFID), and sensor-based technologies help monitor and detect potential risks while working at high or in confined spaces (Ashton, 2009; Magrassi and Berg, 2009; Park et al., 2013; Dong et al., 2017; Haupt et al., 2019; Osunsanmi et al., 2019). In addition, this buttressed the study findings by Zhang et al. (2017) that global posting systems (GPS) and radiofrequency identification (RFID) help monitor workplace activities, transfer communication, and detect dangerous regions' reports on any impending risks.

Therefore, construction stakeholders will require professional development (workshops, training, conferences, and seminars) to enhance their knowledge of data and robotic technologies, process-based automation technologies, output communication technologies, and hazard detective wearables to improve H&S practices in project delivery. This will increase awareness of 4IR technologies in H&S practices among construction stakeholders in all states in Nigeria.

The component correlation matrix in Table 8 shows the relationship between the component variables with values around 0.300. This indicates the existence of a positive relationship between these components. Also, the reliability test was conducted on the variables in each component, indicating that the variables measured are valid for their component.

5 Conclusion and recommendation

The study investigates awareness of 4IR technologies in H&S practices among construction professionals in the Nigerian construction industry. An extant literature review identified sixteen 4IR technologies for H&S practices in construction project delivery. These enabling technologies include augmented reality, robotics and automation and sensor-based technologies, drones, big data, unmanned aerial vehicles (UAV), Internet of things (IoT), photogrammetry, geographical information system (GIS), and virtual reality wearable technology and smart PPE, radiofrequency identification (RFID), building information modelling (BIM), 3D printing and 4D computer-aided design (4D CAD) and laser scanning. The descriptive analysis findings show that the professionals are generally aware of 4IR technologies in H&S practices in Lagos, Nigeria. The Kruskal–Wallis H test revealed no significant difference in professionals' awareness of 4IR technologies in H&S practices in the construction project delivery in Lagos, Nigeria. The exploratory factors analysis further produces a four-factor component of 4IR technologies in H&S practices for the Nigerian construction industry: data and robotic, process-based automation, output communication, and hazard detectives' wearable.

The findings of this study provide a theoretical, practical understanding and innovative approaches to construction firms, government agencies, stakeholders, and professional institutions to improve workplace H&S practices in the construction project delivery in the Era of 4IR. It also helps to keep accurate data, track progress, and monitor real-life activities and decision-making that promote construction firm health and safety practices in the Nigerian construction industry. Health and safety enabling technologies will help professionals better understand H&S practices in the Era of 4IR within the Nigerian construction industry. It also assists construction managers and safety officers in developing an effective construction process and improve safe construction work in the Nigerian construction industry.

The study concludes that construction professionals need to increase awareness of 4IR technologies in H&S practices construction delivery across all states in Nigeria among private and public clients. In addition, the professional bodies in the built environment also need to improve awareness among the public sector on 4IR technologies in H&S practices to reduce occupational accidents in construction project delivery. In line with these findings, the study recommends continuous construction professionals' training, workshops, conferences, and seminars on enabling 4IR technologies for H&S practices to improve construction professionals' knowledge of its usage and application. As shown in the study, this is important because professionals within the construction industry often face challenges in adopting new technologies due to knowledge gaps. Thus, continuous training initiatives, workshops, conferences, and seminars can bridge this gap by providing professionals and policymakers within the construction industry with insights into the capabilities of 4IR technologies and how they align with H&S practices for different construction activities.

The study also recommends that stakeholders in the construction industry to better adopt and integrate 4IR technologies for improved H&S practices outcomes should incorporate its usage from the design stage of the construction process. This study data is limited to selected construction stakeholders in Lagos, which does not adequately represent the diversity of stakeholders within the Nigerian construction industry, making the findings not accurately reflect the broader trends and perspectives of the industry in the study area. However, the findings are largely similar to other geographical construction industry contexts, which makes the study findings only applicable to the Nigerian construction industry. Based on this limitation, further study can design qualitative research involving stakeholders from all the States in Nigeria to compare the knowledge of H&S practice in the Era of 4IR and to determine parameters to measure 4IR technologies in H&S practices in Nigeria and developing countries.

Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

Author contributions

Conceptualisation, BO and OA; methodology, OA, BO, and CA; resources, OA and BO; writing—original draft preparation, OA and BO; writing—review and editing, BO, CA, and OA; visualisation, OA and BO; supervision, BO and CA; project administration, BO, CA, and OA. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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