Article

Exploring the Current Technologies Essential for Health and Safety in the Ghanaian Construction Industry

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Abstract: Technology has undoubtedly played a vital role in improving construction procedures and processes for many years. However, its application for health and safety monitoring and management has not been fully exploited in the Ghanaian construction industry. This study aims at exploring the current technologies essential for health and safety in the Ghanaian construction industry. Three specific objectives are set: (1) to identify the current health and safety technologies important in the Ghanaian construction industry; (2) to examine the level of utilization of the current health and safety technologies in the Ghanaian construction industry; (3) to identify the barriers to the adoption of the current health and safety technologies in the construction industry. A structured questionnaire is used to solicit the views of 123 construction professionals who double as health and safety officers in large construction firms in Ghana. The questions are developed through a critical comparative review of the related literature. The data are analyzed via descriptive and inferential statistics. The findings reveal that key among the current technologies important for health and safety in the Ghanaian construction industry are wearable safety devices, geographic information systems, sensing technologies, virtual reality, and BIM. The findings further reveal a moderate level of usage of the key technologies among construction professionals in Ghana. Key among the barriers to the adoption of these technologies for health and safety in the Ghanaian construction industry are the factors 'excess costs related to acquiring new technologies', 'weak innovation culture', 'lack of continuous training of the workforce in adapting to the technologies', 'resistance to change with aging workforce', and 'little or no governmental support and regulations for the use of the technologies'. The findings from this study provide insight into the ever-increasing state-of-the-art technologies used in the construction industry.

Keywords: health and safety; current technology; construction industry; Ghana

1. Introduction

The construction industry (CI) remains a significant contributor to the economy of every country [1–3]. In 2015 and 2016, the CI contributed over $650 billion to the gross domestic products (GDPs) of countries globally [3]. The welfare of the workforce of the construction sector is extremely important, as their contributions improve productivity and work quality through the production of high-performance buildings and other civil works [3]. Nnaji and Karkhan [3] further argued that the negative challenges faced by the building construction workforce affect the desired productivity and quality of their work. This can lead to economic losses. In addition, these negative challenges are observed in the area of construction site safety. Yearly, hundreds of lives are lost to construction site injuries and accidents and the numbers are worse for developing countries [3,4].

Construction health and safety has been one of the long-standing and enormous areas of research in the literature. It has also been a great concern in management practice [5–7].

According to Awolushi et al. [8], workers in the construction sector face the highest rates of occupational illnesses and injuries despite the health and safety procedures that have been laid down by the Occupational Safety and Health Authority (OSHA). To better improve the practices of health and safety on construction projects, various forms of education and training have been introduced on many construction sites across the world [6]. Various studies have been undertaken to explore the attitudes of construction workers towards safety practices based on certain factors, such as age and safety performance attitudes in Australia [6]. According to Williams et al. [4], one of the effective and efficient ways for implementing safety management is through the creation of a safety culture within the organization. Additionally, improving the safety of construction sites should be a priority for most construction firms.

In Ghana, although construction professionals are fully aware of the safety management programs as enshrined in various regulatory acts [9], the industry still contributes to the growing number of accidents and fatalities in its workforce [9]. The building industry has been a major contributor to socio-economic development in Ghana, yet the nature of most construction sites is hazardous, leading to work-related injuries and fatalities [9,10]. For many years, there has been an outcry for policy reform concerning health and safety in the CI, as the industry continues to be dangerously hazardous in many parts of the world [6].

Due to the high proportions of fatalities and accidents observed in the CI, many construction firms constantly seek new and advanced approaches to promote health and safety on construction sites [8]. It has been argued that new technologies may be the way forward for better safety and health practices [7]. The past twenty years have seen the introduction and incorporation of some digital techniques and technologies towards advancing construction health and safety practices and management [7,11]. These technologies include building information modeling (BIM), tracking and positioning technologies, and artificial intelligence, amongst others [7,11]. According to Guo et al. [7] and Guo et al. [12], these technologies have proven to be of great reliance and are of significance to countries and industries that have adopted them in health and safety planning, training and education, and management. Previous studies on construction health and safety have focused on the areas of management, policy, and human and cultural aspects of safety [4,7]. These areas cover certain dimensions such as human factors in construction health and safety, strategic management for health and safety, and effective planning to prevent hazards and accidents [7]. For some time now, the management of health and safety practices in the construction sector has been manual, selective, time-consuming, inefficient, and error-prone [5,7]. Guo et al. [12] postulated that with the traditional methods of monitoring and inspections, it is difficult to cover the whole site and to also observe all workers. Guo et al. [12] further stated that the traditional approaches were paper-based hazard recognition systems that would hinder timely risk communication. In advanced countries, technology has undoubtedly played a vital role in the improvement of many construction procedures and processes. Notwithstanding, its application for construction health and safety monitoring and management has not been fully exploited in the CI in developing African countries such as Ghana [8]. Although several technologies can manage health and safety in the CI in general, the CI in Ghana has been slow in its adoption because it heavily depends on manpower or manual labor for most of its activities. This problem has led to a higher level of health and safety issues in the industry. In a recent study conducted by Amissah et al. [13] among 634 frontline construction workers in the Kumasi Metropolis in Ghana alone, it was revealed that injury was prevalent among 57.91% of workers, open wounds were prevalent among 37.29%, and fractures were prevalent among 6.78%. These data refer to frontline workers in the construction industry in only one out of the sixteen regions in Ghana where construction activities are rampant. This indicates that the overall percentage of workers that encounter accidents and fatalities in Ghana could increase if appropriate measures are not put in place. In a recent study by Danso et al. [14], it was revealed that in Ghana, safety risk perceptions and local cultures are two serious determinants that influence construction site workers' risk-taking behaviors.

In a study by Adinyira et al. [15], it was revealed that there are a good number of unsafe behaviors exhibited by workers in the Ghanaian construction industry. Notwithstanding the findings from these recent studies, there are inadequate measures in place that can check the outcomes of these unsafe behaviors that eventually lead to accidents and fatalities on construction sites. It will be a step in the right direction if a call is made for current technologies to be adopted in the Ghanaian construction industry to control this problem.

As a step in promoting the use of technologies to enhance health and safety in the GCI, this study aims to examine the views of construction professionals on certain technologies that are essential for health and safety delivery in the CI. To achieve this aim, three specific objectives are set: (1) to identify the current health and safety technologies important in the Ghanaian construction industry; (2) to examine the level of utilization of the current health and safety technologies in the Ghanaian construction industry; (3) to identify the barriers to the adoption of current health and safety technologies in the construction industry. This research will add value to the many studies that already exist on the subject, because it is the first time a study has been conducted in Ghana to explore the health and safety technologies important for the Ghanaian construction industry. The study goes on to further identify the level of importance that industry professionals attach to various construction health and safety technologies. It also identifies the state of utilization of these technologies and the barriers hindering the use of these technologies in the Ghanaian construction industry. The findings have the potential to position the Ghanaian construction industry to begin exploring ways through which the use of these technologies could be enhanced to control the construction industry's health and safety issues.

2. Literature Review

Since this study was about exploring the current technologies essential for health and safety in the GCI, a critical comparative review of the related literature in the form of microscoping was conducted. The review regarding the technologies (i.e., their identification, importance, utilization, and barriers) was restricted only to published studies in the English language. These studies were identified through a keyword search. The keywords used included: health and safety; health and safety technologies; important health and safety technologies; utilizing health and safety technologies; barriers to adopting health and safety technologies. The search was performed in major literature databases and search engines such as Scopus, Taylor and Francis, Emerald, Wiley Inter Science, and Science Direct. The review covered fifteen years, i.e., from 2007 to 2022. The sections that follow bring out some of the details uncovered.

2.1. Health and Safety in the Ghanaian Construction Industry

The GCI poses as one of the boosters of the economic sector through employment and gross domestic product (GDP) contributions [2,9]. There has been a steady growth in GDP contribution over the years, with a peak value of 13.7% in 2016 [2]. The GCI has a very high projected industrial growth rate of 19%; however, the high rates of fatalities, accidents, and deaths pose a greater threat to the projected reported industrial growth [2].

The activities of most firms affect the development of the CI in one way or another. There are also public institutions and non-governmental organizations that directly interact with the industry by regulating activities on behalf of the government. These institutions include financiers, suppliers, trade unions, research institutions, educational institutions, donor agencies, and private clients [2]. The Ministry of Water Resources, Works, and Housing in Ghana is directly responsible for the building CI. This ministry, together with other departments, ensures that every form of building project satisfies all relevant legal requirements for building in Ghana. For example, the labor department at the Ministry of Manpower Development and Employment is responsible for employment and labor issues, while the Factory Inspectorate and the Occupational Health Unit of the Ministry of Health are in charge of occupational health and safety issues [2]. In addition, the safety management of the CI is of great concern to all stakeholders in the Ghanaian construction

sector. Their involvement was also emphasized to be very vital in combating the health and safety issues currently faced in the industry as posited by Osei-Asibey et al. [16].

According to Agyekum et al. [9], the GCI heavily relies on labor-intensive methods in its production processes. However, their activities pose significant health and safety risks to skilled workers. Laryea [17] reported that even though the industry is full of plentiful cheap labor, the demand for adequate skills amongst artisans and tradesmen is woefully met. Just as the industry keeps evolving, the construction workforce must in turn evolve to suit the new demands. The CI is hailed as a sector that employs a large number of unskilled laborers. This has in some way contributed to the negative image of having very poor health and safety records [17]. Laryea [17] stated that the GCI faces poor safety performance and poor records for health and safety due to a lack of training programs and a lack of adjustment to new health and safety methods and approaches, as well as a lack of technical know-how for evolving safety measures.

2.2. Health and Safety Issues in the Global Construction Industry

Issues related to occupational health and safety at the workplace are of enormous concern when it comes to the CI [4,15,16]. In the past decades, the CI has been known to be one of the most hazardous industries in the world due to the work-related deaths and injuries it causes [4,18–20]. According to Forat et al. [19], the monitoring of work-related hazards should be a shared responsibility for every worker on a construction project, and not just the duty of management.

Generally, the rate of occurrence of accidents, fatalities, and deaths on construction sites across the world is close to 40% [19,21]. About 16% and 22% of the global workforce were accounted to be involved in fatal occupational injuries in America and the UK, respectively, whiles employing between 5% and 10% of the global workforce [1,4,18]. The CI in India also recorded about 16% of the occupational accidents in relation to the global number of accidents in 2016 [1,22]. According to Abas [20], Malaysia's yearly records for cases of fatalities are very alarming. In 2007, the total number of fatalities reported to DOSH was 219, which increased to 230 in 2008. The total number of fatalities reported in 2021 was 217, which is very alarming.

The causes of these fatalities include falls, being struck by falling objects, and electric shocks [20]. Due to these high records of accidents and injuries, the management of occupational health and safety in the industry is very critical [3,19]. As one of the objectives of the construction project success, health and safety is regarded as an essential element related to time, quality, and cost. Furthermore, the negative impact of health and safety on construction projects has affected the reputation of the industry [3,19].

2.3. Health and Safety Technologies Used in the Construction Industry

Over the past decades, the application of technology in the CI has received enormous attention [3,23]. Most of these technologies were initially adopted to improve the quality and efficiency of the construction process and products, and also to reduce costs to improve benefits. However, in recent times, more construction technologies are being used in the management of health and safety. These technologies are used in diverse ways to mitigate hazards in the workplace [3,24].

The traditional methods of dealing with safety performance are largely manual and based on subjective opinions. These approaches are costly, prone to errors, and not sufficient for efficient and successful project control [8]. To overcome the limitations that are tied to the manual methods of monitoring and managing health and safety on construction projects, the automated monitoring system was recommended as a better approach to monitoring and managing health and safety [8,24–26]. According to Mihic et al. [24], the use of HSTs to improve health and safety is not a new occurrence, although the CI has been experiencing its usage in the last decades. In the views of Awolusi et al. [8], among the engineering approaches to monitoring safety on construction sites, wearable technologies enable continuous monitoring of the health and safety of workers over a wider range.

Forat et al. [19] also reported that these wearable technologies come in handy as they identify potential hazards. They also send notifications of accidents or injuries within a specific place on the worksite. Furthermore, they give out warning alerts through sounds and vibrations whenever potential dangers are identified. Wearable safety devices (WSDs) are attracting substantial attention in the industry and in academia. The WSDs are small, light devices that workers can wear or attach to their outfits, bodies, or other accessories that monitor the state of health or improve the safety of workers as they work [3,8,19].

Nnaji and Krarakhan [3] further stated that these devices are not cumbersome, are highly efficient, and are also not expensive. They are equipped to check fatigue levels, assess physical workloads, prevent musculoskeletal disorders, prevent work falls, monitor mental status, and evaluate the hazard recognition abilities of field workers as well as managers. Akinlolu et al. [23] and Forat et al. [19] further stated that most of these wearable devices, such as hats, vests, and glasses, are equipped with smart technologies such as sensors, GPS, real-time location systems, and more to achieve safety goals and reduce accidental risks.

According to Akinlolu et al. [23] and Haupt et al. [27], safety and health managers mostly use virtual and augmented reality (VR and AR) to evaluate safety tie-off points and generate a genuine health and safety work experience through virtual drills, instructions, and health and safety scenarios viable for construction health and safety training. These technologies also help in managing workers in the CI [3]. An emerging health and safety technology that boosts the strength and endurance of users is the exoskeleton [23,27,28]. The unpowered exoskeletons provide a feeling of weightlessness, redistribute weight, and improve the posture of the user when carrying heavy objects [28]. According to Akinlolu et al. [23] and Lakhiar et al. [28], radiofrequency identification (RFID) technology has been used for some time to demonstrate real-time data collection. It is used to track the movements of equipment, workers, and materials. The resulting data are examined to determine if a near-miss incident has occurred and are further used to prevent such occurrences in the future. Sensing technologies (laser scanning, radar, sonar, global positioning system, cameras) provide innovative methods for the advancement of real-time construction health and safety. As a viable technique, the application of wireless sensor networks used for forecasting and environmental monitoring could assist in the avoidance of accidents and lead to improved construction site health and safety performance [23,27,28].

In the views of Mihic et al. [24], the research has revealed some health and safety-related innovative technologies used in various activities, including safety training, sensing and warning, site safety planning, safety risk drivers, hazard identification, job hazard analysis (JHA), visualization, design for safety suggestions, rule checking, and construction planning. These technologies include BIM, geographic information system (GIS), augmented reality (AR), ontology and natural language processing (NLP), sensing (laser scanning, radar, sonar, global positioning system, cameras), radiofrequency identification (RFID), four-dimensional computer-aided design (4D CAD), augmented virtuality (AV), virtual reality (VR), knowledge-based systems, and database integration technologies [23,24,27].

2.4. Barriers to the Adoption of Current Health and Safety Technologies (HSTs) in the Construction Industry

Emerging technologies have been proven to be of great reliance and significance to countries and industries that have adopted them in the planning, training and education, and management of health and safety on construction projects [7,12,19,25]. Although they have been argued to be the way forward for health and safety practices, there are some barriers or limitations to the adoption of these technologies [7,11,25].

According to Nnaji and Karakhan [3], a plethora of researchers have suggested several barriers to the use or adoption of health and safety technologies. Some argued that the excess costs related to acquiring new technologies were a factor. Others argued that the decisions to use these technologies varied with the clients of a project. Others also stated that the aging workforce mostly resists change, and as emerging technologies usually look cumbersome,

their adaptation is very slow initially [3,6,28]. The privacy of workers' health data is not guaranteed, there are very low profit margins in the industry, there are limited opportunities to observe and try health and safety technologies, there are few or no recognized standards for operation, there are liability concerns, there is little or no information on the effectiveness of the safety and health technologies, there is little or no governmental support and no regulations for the use of these technologies, there is a lack of continuous training of the workforce in adapting to these technologies, there is limited use of digital modeling, and there is weak innovation culture, as was realized from the literature [3,8,17,26].

3. Materials and Methods

This study sought to explore the current technologies essential for health and safety in the GCI. A quantitative research method was employed. This method was deemed necessary because it allows for the use of structured questionnaire surveys, which enable researchers to generalize their findings among the larger population.

3.1. Survey Design and Administration

Following a comparative review of the related literature, a questionnaire was prepared to collect the quantitative data. A sample of the questionnaire can be seen in Appendix A. According to Rowley [29], a questionnaire is more appropriate for collecting data when the intent of the study is to capture and measure the frequency of opinions, attitudes, experiences, processes, behaviors, and predictions, among others. The questionnaire used in this study was divided into four sections (see Appendix A). Each section of the questionnaire was a stand-alone section and was intended to collect data from the respondents regarding a specific issue.

The first section of the questionnaire sought information on the respondents' demographic background. The demographic information sought included the respondents' gender, level of education, professional role, and years of professional experience.

The second section of the questionnaire sought information on the level of importance that the respondents attached to the current health and safety technologies in the Ghanaian construction industry (see Appendix A). In this section, the respondents were required to rate on a Likert scale of 1 to 5 (where 1= not important, 2 = less important, 3 = moderately important, 4 = important, and 5 = very important) the level of importance they attached to the current technologies important for health and safety in the Ghanaian construction industry.

The third section of the questionnaire sought information on the respondents' level of utilization of the current health and safety technologies in the Ghanaian construction industry (see Appendix A). In this section, the respondents were required to rate on a Likert scale of 1 to 5 (where 1 = not utilized, 2 = least utilized, 3 = moderately utilized, 4 = utilized, and 5 = highly utilized) their level of utilization of the current health and safety technologies in their various firms.

The fourth section of the questionnaire sought information on the factors that hindered the adoption of the current health and safety technologies among the respondents in their various firms (see Appendix A). In this final section, the respondents were required to rate on a Likert scale of 1 to 5 (where 1= not significant, 2 = less significant, 3 = moderately significant, 4 = significant, and 5 = highly significant) the barriers to the adoption of the current health and safety technologies in the Ghanaian construction industry.

After the draft questionnaire was prepared, it was validated through piloting. The piloting involved fifteen (15) health and safety professionals. Three (3) of these professionals were in academia and twelve (12) were practicing health and safety officers with various construction firms in Ghana. The piloting was conducted through a face-to-face interview session with the respondents. The piloting ensured the suitability of the research instrument for the intended purpose. After the piloting, the fifteen respondents revealed that the contents and composition of the questionnaire were adequate to achieve the aim and specific objectives of this study.

Therefore, the final set of questionnaires was administered to the respondents online via Google Forms. This data collection method was considered adequate because compared with other data collection methods such as face-to-face, the anonymity of the respondents is guaranteed.

The population used in this study comprised construction professionals such as project managers, architects, engineers, quantity surveyors, and contractors who doubled as health and safety officers in large construction firms in Ghana. Due to the difficulties involved in getting the exact number of professionals who knew how to use safety and health technologies in the Ghanaian construction economy, a combination of the purposive and snowball sampling techniques was employed in the research study.

The purposive sampling technique was used to obtain the initial set of respondents who are known to use various technologies to monitor their construction health and safety. Key criteria were set to assist the researchers to identify these initial sets of respondents. Among the criteria were that the target respondents must be working in a known large construction company in Ghana, the respondent must have an idea of any of the health and safety technologies listed in Appendix A and the respondent must be able to lead the researchers to other large construction firms operational in Ghana that employ any of these technologies in monitoring their health and safety issues. Through referrals from the previously identified respondents, the snowball sampling technique was used to reach other respondents who could not be easily located by the researchers.

Out of the 150 questionnaires distributed, 123 were retrieved, representing eighty-two percent (82%) of the total number of questionnaires distributed, sorted, and prepared for analysis.

3.2. Data Analyses and Interpretation

The data retrieved from the respondents were analyzed using the Statistical Package for Social Sciences (SPSS) version 26. The consistency of responses (i.e., reliability) of the data from the completed questionnaires was checked using Cronbach's alpha. The alpha values obtained for the current health and safety technologies important in the GCI, the level of utilization of the current health and safety technologies, and the barriers to the adoption of the current health and safety technologies were 0.963, 0.975, and 0.949, respectively, indicating that the data were reliable for the analysis. The data were subsequently analyzed using mean score ranking (MSR) and a one-sample *t*-test.

The one-sample *t*-test is a statistical hypothesis test used to compare the mean of a sample to a predefined value to determine whether the sample mean is significantly greater or less than the predefined value. The predefined value is the test value. In this study, the one-sample *t*-test was conducted to check the various means against a mean test value of 3.5. It was conducted at a 95% confidence level with a *p*-value of 0.05. The null hypothesis (H_0) was rejected when $p < 0.05$ at the 95% confidence level. The alternative hypothesis held when $p > 0.05$ at the 95% confidence level. The null hypothesis in this study was defined to mean that the mean scores of the importance, utilization, and barriers were not statistically significant. The alternative hypothesis was defined to mean otherwise.

4. Results

The results of this study are presented under four subsections to include the respondents' demographic profile, the current technologies important for health and safety in the CI, the level of utilization of the current health and safety technologies (HSTs) identified, and the barriers to the adoption of these technologies.

4.1. Respondents' Demographic Profile

The respondents were asked to provide information such as their gender, highest level of education, professional role, and years of professional experience. According to Research Optimus [30], a frequency analysis performed on the demographics of research participants can provide clear characteristics of the participants in a study. Table 1 shows a summary of the characteristics of the respondents.

Table 1. Demographic Information.

Demographic	Frequency	Percentage (%)
Gender		
Male	102	82.9
Female	21	17.1
Highest level of education		
HND	6	4.9
Bachelor's degree	72	58.5
Master's degree	42	34.1
Doctorate	3	2.4
Professional role		
Project Manager	33	26.8
Architect	9	7.3
Engineer	33	26.8
Quantity Surveyor	33	26.8
Contractor/construction manager	15	12.2
Years of professional experience		
0–2 years	24	19.5
3–5 years	39	31.7
6–8 years	18	14.6
9–12 years	12	9.8
Above 12 years	30	24.4

From Table 1, the respondents were made up of 102 (82.9%), males forming the majority, and 21 (17.1%) females. The respondents were health and safety officers who doubled in professional construction roles, including project managers (26.8%), architects (7.3%), engineers (26.8%), quantity surveyors (26.8%), and contractors or construction managers (12.2%). The qualifications of these professionals were in the order of doctorate degrees (2.4%) followed by master's degrees (34.1%), with the majority (58.5%) being bachelor's degree holders, then lastly followed by higher national diploma (HND) (4.9%) holders in related disciplines. The working experience revealed that 39 (31.7%) of the respondents had 3–5 years of working experience in their relative professions. Twenty-four (24) had less than 3 years of working experience, 18 (14.6%) had between 6 and 8 years of working experience, 12 (9.8%) had between 9 and 12 years of working experience, and 30 (24.4%) had more than 12 years of working experience in their relative profession.

4.2. Current Technologies Important for Health and Safety in the Ghanaian Construction Industry

Based on the rankings (Table 2) corresponding to the perceptions of the professionals, the most important current technologies for health and safety are in the following order: wearable safety devices (WSDs) (mean score (MS) = 4.27, standard deviation (SD) =1.215), geographic information system (GIS) (MS = 3.98, SD = 1.225), sensing technologies (MS = 3.78, SD = 1.322), virtual reality (VR) (MS = 3.73, SD = 1.215), BIM (MS = 3.68, SD = 1.244), augmented reality (AR) (MS = 3.68, SD = 1.263), artificial intelligence (MS = 3.63, SD = 1.189), augmented virtuality (AV) (MS = 3.63, SD = 1.210), robots and automation (MS = 3.63, SD = 1.269), radiofrequency identification (RFID) (MS =3.59, SD = 1.214), exoskeletons (MS = 3.54, SD = 1.176), and unmanned aerial vehicles (MS = 3.49, SD = 1.295).

Table 2. A summary analysis of the current technologies important for health and safety in the Ghanaian construction industry.

No	Technologies	T	Mean	S.D.	Test Value = 3.5 Sig. (2-Tailed)	Rank	Statically Significant
1	Wearable safety devices (WSDs) such as hats, vests, and glasses	7.012	4.268	1.2152	0.000	1	Yes
2	BIM	1.632	3.683	1.2435	0.105	5	No
3	Unmanned aerial vehicles	−0.104	3.488	1.2954	0.917	12	No
4	Artificial intelligence	1.251	3.634	1.1892	0.213	7	No
5	Exoskeletons	0.345	3.537	1.1755	0.731	11	No
6	Robots and automation	1.172	3.634	1.2692	0.243	9	No
7	Geographic information system (GIS)	4.308	3.976	1.2245	0.000	2	Yes
8	Augmented reality (AR)	1.606	3.683	1.2631	0.111	6	No
9	Sensing technologies (laser scanning, radar, sonar, global positioning system, cameras)	2.354	3.780	1.3216	0.020	3	Yes
10	Radiofrequency identification (RFID)	0.780	3.585	1.2142	0.437	10	No
11	Augmented virtuality (AV)	1.230	3.634	1.2097	0.221	8	No
12	Virtual reality (VR)	2.115	3.732	1.2152	0.036	4	Yes

While the mean score ranking only showed the professionals' views of the extent to which the current technologies examined are important to health and safety in the GCI, a one-sample *t*-test was used to indicate the statistical significance of the various technologies for health and safety within the GCI. Table 2 shows that all factors had *t*-values (strength of the test) that were positive, indicating that their means were above the hypothesized mean of 3.5, except for unmanned aerial vehicles, which had a *t*-value of (−0.104). This was because it had a mean of 3.488, which was slightly below the hypothesized mean of 3.5. Wearable safety devices (WSDs), geographic information systems (GIS), sensing technologies, and virtual reality (VR) had *p*-values of less than 0.05 for the one-sample *t*-test, giving a strong indication of the statistical significance of these current technologies to health and safety in the GCI.

4.3. Level of Utilization of Current Health and Safety Technologies in the Ghanaian Construction Industry

Based on the ranking as corresponding to the perception of the professionals' views of the utilization of current health and safety technologies (see Table 3), the highly used HSTs are in the following order: wearable safety devices (WSDs) (mean score (MS) = 4.00, standard deviation (SD) =1.235), BIM (MS = 3.46, SD = 1.295), geographic information system (GIS) (MS = 3.39, SD = 1.291), sensing technologies (MS = 3.37, SD = 1.433), virtual reality (VR) (MS = 3.24, SD = 1.399), artificial intelligence (MS = 3.17, SD = 1. 401), radiofrequency identification (RFID) (MS =3.17, SD = 1. 503), unmanned aerial vehicles (MS = 3.10, SD = 1. 399), augmented reality (AR) (MS = 3.07, SD = 1.319), exoskeletons (MS = 3.07, SD = 1. 338), robots and automation (MS = 3.05, SD = 1. 366), and augmented virtuality (AV) (MS = 3.05, SD = 1. 470).

While the mean score ranking only showed the professionals' views of the level of usage of the current technologies in the GCI, a one-sample *t*-test was used to indicate the statistical significance of the usage of the various technologies to health and safety within the GCI. Table 3 shows that all factors had *t*-values (showing the strength of the test) that were negative, indicating that their means were below the hypothesized mean of 3.5, except for wearable safety devices (WSD), which had a *t*-value of 4.491. This was because this category had a mean of 4.000, which was above the hypothesized mean of 3.5. Wearable

safety devices (WSDs), unmanned aerial vehicles, artificial intelligence, exoskeletons, robots and automation, augmented reality (AR), radiofrequency identification (RFID), augmented virtuality (AV), and virtual reality (VR) had *p*-values less than 0.05 for the one-sample *t*-test, giving a strong indication of the statistical significance of these current technologies' usage in the GCI.

Table 3. Use of current health and safety technologies in the Ghanaian construction industry.

No	Technologies	T	Mean	S.D.	Test Value = 3.5 Sig. (2-Tailed)	Rank	Statically Significant
1	Wearable safety devices (WSDs) such as hats, vests, and glasses	4.491	4.000	1.2347	0.000	1	Yes
2	BIM	−0.313	3.463	1.2950	0.755	2	No
3	Unmanned aerial vehicles	−3.190	3.098	1.3991	0.002	8	Yes
4	Artificial intelligence	−2.607	3.171	1.4009	0.010	6	Yes
5	Exoskeletons	−3.538	3.073	1.3378	0.001	10	Yes
6	Robots and automation	−3.663	3.049	1.3662	0.000	11	Yes
7	Geographic information system (GIS)	−0.943	3.390	1.2908	0.348	3	No
8	Augmented reality (AR)	−3.588	3.073	1.3193	0.000	9	Yes
9	Sensing technologies (laser scanning, radar, sonar, global positioning system, cameras)	−1.038	3.366	1.4330	0.301	4	No
10	Radiofrequency identification (RFID)	−2.430	3.171	1.5025	0.017	7	Yes
11	Augmented virtuality (AV)	−3.404	3.049	1.4702	0.001	12	Yes
12	Virtual reality (VR)	−2.031	3.244	1.3987	0.044	5	Yes

4.4. Barriers to the Adoption of Current Health and Safety Technologies in the Construction Industry

Based on the ranking as corresponds to the professionals' views on the significant barriers to the adoption of the current HSTs, the highly significant barriers to the adoption of the current HSTs are in the following order (see Table 4): 'excess costs related to acquiring new technologies' (mean score (MS) = 4.46, standard deviation (SD) = 0.862), 'weak innovation culture' (MS = 4.29, SD = 0.894), 'lack of continuous training of workforce in adapting to the technologies' (MS = 4.20, SD = 1.069), 'resistance to change with aging workforce' (MS = 4.12, SD = 1.021), and 'little or no governmental support and regulations for the use of the technologies' (MS = 4.05, SD = 1.015).

A one-sample *t*-test was further used to establish the relative significance of the variables. From Table 4, all factors had *t*-values (the strength of the test) that were positive, indicating that their means were above the hypothesized mean of 3.5. Additionally, all factors had *p*-values (showing the significance of the test) of less than 0.05, giving a strong indication of the statistical significance of the various obstacles that hinder the usage of the current technologies for health and safety in the GCI.

Table 4. Barriers to the adoption of current health and safety technologies in the construction industry.

No	Technologies	T	Mean	S.D.	Test Value = 3.5 Sig. (2-Tailed)	Rank	Statically Significant
1	Excess costs related to acquiring new technologies	12.400	4.463	0.8617	0.000	1	Yes
2	The decision of clients of projects	4.641	3.902	0.9617	0.000	9	Yes
3	Resistance to change with the aging workforce	6.756	4.122	1.0210	0.000	4	Yes
4	Cumbersome outlook of technologies	4.816	3.951	1.0390	0.000	7	Yes
5	Very low profit margins in the industry	4.522	3.902	0.9869	0.000	10	Yes
6	Limited opportunities to observe and try technologies	4.770	3.902	0.9358	0.000	8	Yes
7	Little or no recognized standards for operation	3.235	3.829	1.1287	0.002	11	Yes
8	Little or no information on the effectiveness of the technologies	3.572	3.805	0.9466	0.001	12	Yes
9	Little or no governmental support and regulations for the use of the technologies	5.996	4.049	1.0151	0.000	5	Yes
10	Limited use of digital modeling	5.331	4.000	1.0402	0.000	6	Yes
11	Weak innovation culture	9.836	4.293	0.8938	0.000	2	Yes
12	Lack of continuous training of the workforce in adapting to the technologies	7.214	4.195	1.0686	0.000	3	Yes

5. Discussion

5.1. Current Health and Safety Technologies Important in the Ghanaian Construction Industry

From Table 2, the respondents on average showed a high level of importance (the mean score ranged between 3.49 and 4.27 for the identified current technologies in tackling health and safety issues). This showed that when it comes to health and safety, stakeholders perceive the use of technologies as important and that all the variables are important in tackling health and safety in the GCI. Professionals also asserted that WSDs are important for the Ghanaian construction industry. This revelation conforms to the studies by Awolushi et al. [8]. Awolushi et al. [8] stated that technology plays a vital role in the improvement of many construction procedures and processes. Health and safety is indeed an important aspect of construction that also requires the employment of current technologies to effectively monitor site employees against any harm. The study also agrees with that by Nnaji and Karakhan [3], Awolushi et al. [8], and Forat et al. [19], who posited that wearable safety devices (WSDs) are attracting substantial attention in the industry and academia. According to Forat et al. [19], wearable safety devices such as helmets, goggles, vests, headbands, or watches can be equipped with technologies such as GPS, Internet connections, and other monitoring devices to aid in reducing fatalities and injuries associated with construction works on site. This was also in conformity with the study by Mihic et al. [24]. These wearable devices and sensing technologies can give off warning sounds when danger is sensed by the devices. The danger could be internal (vital and other related health conditions of the employees or wearers) or external (working conditions and hazardous areas). These technologies can safeguard both the workers and also the construction works from destruction [3,19,24]. According to Mihic et al. [24], Haupt et al. [27], and Akinlolu et al. [23], BIM, geographic information system (GIS), sensing (laser scanning, radar, sonar, global positioning system, cameras), radiofrequency

identification (RFID), four-dimensional computer-aided design (4D CAD), augmented virtuality (AV), virtual reality (VR), knowledge-based systems, and database integration technologies will enhance health and safety in the CI if they are employed.

5.2. Level of the Utilization of the Current Health and Safety Technologies in the Ghanaian Construction Industry

From Table 3, the respondents showed a low level of utilization of the current HSTs. Most of the mean scores were below the mean value of 3.5 for the identified health and safety technologies. This implies that these current HSTs are fairly or rarely used in tackling health and safety issues in the GCI. This finding corroborates that found by Awolushi et al. [8], who indicated that the use of current HSTs is low in the construction industry. There are alarming cases of accidents, injuries, and fatalities on construction sites, but the adoption of these modern technologies in dealing with such cases is not being explored [1,4,18–22]. Although the use of these technologies does not eliminate the dangers associated with working on construction sites, these lower the risk of danger and the recording of high cases of fatalities [20]. A lot can be done with these technologies. They can be used to overcome the limitations that are tied to the manual methods of monitoring and managing health and safety on construction projects. They can also be used to notify accidents or injuries within a specific place on the worksite. They can be used to keep health and safety records, among others [8,24–26]. According to Nnaji and Karakhan [3], several of these technologies are used in the training of workers to enable them to recognize workplace hazards by providing similar real-life cases for their simulations. Utilizing technology for safety management could provide more efficient controls than just training workers to identify workplace hazards.

From the analysis, it was realized that WSDs are mostly used in the GCI, which conforms to the study by Forat et al. [19], who reported that these wearable technologies are attracting substantial attention in the industry and academia because they are small. They are also not cumbersome; hence, workers can wear or attach them to their outfits, bodies, or other accessories to monitor the state of health or to improve the safety of workers as they work [3,8,19]. Nnaji and Karakhan [3] further stated that these devices are highly efficient and also not expensive. They are equipped to check fatigue levels, assess physical workloads, prevent musculoskeletal disorders, prevent work falls, monitor mental health, and evaluate the hazard recognition abilities of field workers as well as managers.

5.3. Barriers to the Adoption of Current Health and Safety Technologies in the Construction Industry

From Table 4, the respondents showed that the various factors were potential barriers to the adoption of the current HSTs (the mean scores were above 3.5). This shows the extent to which adopting these HSTs was tied and limited to the identified barriers. For the GCI, the key barriers to the adoption of the HSTs were 'excess costs related to acquiring new technologies', 'weak innovation culture', 'lack of continuous training of the workforce in adapting to the technologies', 'resistance to change with aging workforce', and 'little or no governmental support and regulations for the use of the technologies'.

This study conforms to the findings by Loosemore and Malouf [6], Delgado et al. [26], and Nnaji and Karakhan [3], who posited that excess costs related to acquiring new technologies and varied decisions to use these technologies by clients of a project were barriers to the adoption of current technologies for health and safety. Most clients believe these current technologies for handling health and safety issues are expensive to acquire and do not yield direct and short-term benefits.

Moreover, the GCI is characterized by poor training of its workers, and this has been a hindrance for workers in embracing changes in the industry. Most of the workers are unable to adapt to the current technologies due to a lack of continuous training in these current technologies [2,18]. Furthermore, developing African countries such as Ghana largely depend on manual or theoretical models to carry out investigations that relate to the causes of accidents on construction sites. The GCI heavily depends on manpower or

manual labor for most of its activities. It also employs a lot of skilled and unskilled laborer's annually, which also indirectly contributes to the national GDP [2]. The level of health and safety is low in the CI, but to a larger extent also depends on the construction workers. Developing an organizational safety and innovation culture is an approach to mitigate this challenge. Developing an innovative culture within the CI will go a long way to making workers embrace changes in the industry, such as the adoption of these new technologies for health and safety.

Studies such as those by Laryea [17], Awolushi et al. [8], Loosemore and Malouf [6], Delgado et al. [26], and Nnaji and Karakhan [3] also agreed that 'the aging workforce mostly resisted change'. Furthermore, 'emerging technologies usually look cumbersome' was a key barrier to the adoption of current health and safety technologies. Aging employees mostly resist the changes and practices taken for a better safety culture. Most of the workers who resist the practices or changes defend their actions by referring to the cumbersomeness of the practices [3,4,8,17,26]. Williams et al. [4] reported that the workforce always got involved in health and safety practices and prevented the punishment of wrongdoing. Due to this, adequate safety measures are difficult to implement. Furthermore, it was reported that workers were found to not comply with the exact instructions regarding safety that were also given to them by the management.

In Ghana, most of the activities of the CI are regulated by the government or regulatory institutions [2,9,17]. It is, therefore, evident in the perceptions of the stakeholders the influence government support and regulations have had on the adoption of health and safety technologies. According to Eyiah et al. [2], the laws and regulations regarding occupational health and safety performance are very weak in Ghana. In addition, barriers such as 'little or no governmental support and regulations for the use of these technologies', 'lack of continuous training of the workforce in adapting to the technologies', 'limited use of digital modeling', and 'weak innovation culture' were also identified in their studies.

6. Conclusions

The purpose of this research was to explore the current technologies essential for health and safety in the GCI. In achieving this aim, three specific objectives were set: (1) to identify the current health and safety technologies important in the Ghanaian construction industry; (2) to examine the level of utilization of the current health and safety technologies in the Ghanaian construction industry; (3) to identify the barriers to the adoption of the current health and safety technologies in the construction industry. The findings revealed that key among the current technologies important for health and safety in the Ghanaian construction industry are wearable safety devices, geographic information systems, sensing technologies, virtual reality, and BIM. The findings further revealed a moderate level of usage of the key technologies. Key among the barriers to the adoption of these technologies for health and safety in the Ghanaian construction industry are the factors 'excess costs related to acquiring new technologies', 'weak innovation culture', 'lack of continuous training of the workforce in adapting to the technologies', 'resistance to change with aging workforce', and 'little or no governmental support and regulations for the use of the technologies'.

These findings have both theoretical and practical implications. Theoretically, the findings contribute to the state-of-the-art by revealing the relevant technologies important for health and safety in the GCI. Practically, the findings could educate regulatory bodies such as the Ghana Institute of Construction on the need to step up and promote the uptake of current technologies in the Ghanaian construction industry. This is important because by enhancing the use of technologies in the workplace, the Ghanaian construction industry can keep up with the regulations and standards whilst providing better working conditions for its employees. Such technologies could enhance the awareness of employees of their workplace hazards and dangers. Furthermore, they can provide construction health and safety officers with high-speed and sophisticated communication tools that are essential to prevent accidents and acting quickly when it occurs. This will assist the construction industry in Ghana in fairly competing with its counterparts in other advanced countries.

The aim of this study was achieved; nonetheless, the study still suffered from certain limitations. Key among these limitations was that the study only targeted respondents from large construction firms to the detriment of the smaller ones. In Ghana, there are four classes of construction firms (i.e., D1 to D4), ranging from large to small. To assist in fairly generalizing the findings of this study, it will be good if future studies consider those construction firms that fall within the classes D2 to D4.

Appendix A

QUESTIONNAIRE
TOPIC:
Exploring the Current Technologies Essential for Health and Safety in the Ghanaian Construction Industry
PART I: BACKGROUND INFORMATION

Please indicate by ticking (✔) appropriately the following to provide your background information

1. Gender

[ ] Male   [ ] Female

2. Highest level of education

[ ] HND   [ ] Bachelor's degree   [ ] Master's degree   [ ] Doctorate degree

3. Profession

[ ] Project manager   [ ] Architect   [ ] Engineer   [ ] Quantity surveyor   [ ] Contractor/Construction Manager [ ]

4. Years of experience in the construction industry

[ ] 0–2   [ ] 3–5   [ ] 6–8   [ ] 9–12   [ ] above 12 years

PART II: IMPORTANCE ATTACHED TO CURRENT HEALTH AND SAFETY TECHNOLOGIES IN THE GHANAIAN CONSTRUCTION INDUSTRY

Please rate on a Likert scale of 1 to 5 (where 1= not important, 2 = less important, 3 = moderately important, 4 = important, and 5 = very important) the level of importance you attach to the current technologies important for health and safety in your firm.

S/N	TECHNOLOGIES	1	2	3	4	5
T 1	Wearable safety devices (WSDs) such as hats, vests, and glasses					
T 2	BIM					
T 3	Unmanned aerial vehicles					
T 4	Artificial intelligence					
T 5	Exoskeletons					
T 6	Robots and automation					
T 7	Geographic information system (GIS)					
T 8	Augmented reality (AR),					
T 9	Sensing technologies (laser scanning, radar, sonar, global positioning system, cameras)					
T 10	Radiofrequency identification (RFID)					
T 11	Augmented virtuality (AV)					
T 12	Virtual reality (VR)					

PART III: LEVEL OF UTILIZATION OF CURRENT HEALTH AND SAFETY TECHNOLOGIES IN THE GHANAIAN CONSTRUCTION INDUSTRY

Please rate on a Likert scale of 1 to 5 (where 1 = not utilized, 2 = least utilized, 3 = moderately utilized, 4 = utilized, and 5 = highly utilized) your level of utilization of the current health and safety technologies in your firm.

S/N	HEALTH AND SAFETY TECHNOLOGIES	1	2	3	4	5
HST 1	Wearable safety devices (WSDs) such as hats and vests and glasses					
HST 2	BIM					
HST 3	Unmanned aerial vehicles					
HST 4	Artificial intelligence					
HST 5	Exoskeletons					
HST 6	Robots and automation					
HST 7	Geographic information system (GIS)					
HST 8	Augmented reality (AR)					
HST 9	Sensing technologies (laser scanning, radar, sonar, global positioning system, cameras)					
HST 10	Radiofrequency identification (RFID)					
HST 11	Augmented virtuality (AV)					
HST 12	Virtual reality (VR)					

PART IV: BARRIERS TO THE ADOPTION OF CURRENT HEALTH AND SAFETY TECHNOLOGIES IN THE GHANAIAN CONSTRUCTION INDUSTRY

Please rate on a Likert scale of 1 to 5 (where 1 = not significant, 2 = less significant, 3 = moderately significant, 4 = significant, and 5 = highly significant) the barriers to the adoption of the current health and safety technologies in the Ghanaian construction industry.

S/N	BARRIERS	1	2	3	4	5
B 1	Excess costs related to acquiring new technologies					
B 2	Th decision of clients of projects					
B 3	Resistance to change with aging workforce					
B 4	Cumbersome outlook of technologies					
B 5	Very low profit margins in the industry					
B 6	Limited opportunities to observe and try technologies					
B 7	Little or no recognized standards for operation					
B 8	Little or no information on the effectiveness of the technologies					
B 9	Little or no governmental support and regulations for the use of the technologies					
B 10	Limited use of digital modelling					
B 11	Weak innovation culture					
B 12	Lack of continuous training of workforce in adapting to the technologies					

References

1. Van Heerden, J.H.; Musonda, I.; Okoro, C.S. Health and safety implementation motivators in the South African construction industry. *Cogent Eng.* **2018**, *5*, 1446253. [CrossRef]
2. Eyiah, A.K.; Kheni, N.A.; Quartey, P.D. An assessment of occupational health and safety regulations in Ghana: A study of the construction industry. *J. Build. Constr. Plan. Res.* **2019**, *7*, 11–31. [CrossRef]
3. Nnaji, C.; Karakhan, A.A. Technologies for safety and health management in construction: Current use, implementation benefits and limitations, and adoption barriers. *J. Build. Eng.* **2020**, *29*, 101–212. [CrossRef]
4. Williams, J.; Fugar, F.; Adinyira, E. Assessment of health and safety culture maturity in the construction industry in developing economies: A case of Ghanaian construction industry. *J. Eng. Des. Technol.* **2020**, *18*, 865–881. [CrossRef]
5. Badri, A.; Boudreau-Trudel, B.; Souissi, A.S. Occupational health and safety in the industry 4.0 era: A cause for major concern? *Saf. Sci.* **2018**, *109*, 403–411. [CrossRef]
6. Loosemore, M.; Malouf, N. Safety training and positive safety attitude formation in the Australian construction industry. *Saf. Sci.* **2019**, *113*, 233–243. [CrossRef]
7. Guo, B.H.; Zou, Y.; Fang, Y.; Goh, Y.M.; Zou, P.X. Computer vision technologies for safety science and management in construction: A critical review and future research directions. *Saf. Sci.* **2021**, *135*, 105–130. [CrossRef]
8. Awolusi, I.; Marks, E.; Hallowell, M. Wearable technology for personalized construction safety monitoring and trending: Review of applicable devices. *Autom. Constr.* **2018**, *85*, 96–106. [CrossRef]
9. Agyekum, K.; Simons, B.; Botchway, S.Y. Factors influencing the performance of safety programmes in the Ghanaian construction industry. *Acta Structilia* **2018**, *25*, 39–61. [CrossRef]
10. Eyiah-Botwe, E.; Aigbavboa, C.O.; Thwala, W.D. Adopting innovative methods in the Ghanaian construction industry. In Proceedings of the 5th Edition of the International Conference on Infrastructure Development in Africa (ICIDA 2016), University of Johannesburg, Johannesburg, South Africa, 10–12 July 2016.
11. Noghabaei, M.; Heydarian, A.; Balali, V.; Han, K. Trend analysis on adoption of virtual and augmented reality in the architecture, engineering, and construction industry. *Data* **2020**, *5*, 26. [CrossRef]
12. Guo, B.H.; Goh, Y.M.; Wong, K.L.X. A system dynamics view of a behavior-based safety program in the construction industry. *Saf. Sci.* **2018**, *104*, 202–215. [CrossRef]
13. Amissah, J.; Badu, E.; Agyei-Baffour, P.; Nakua, E.K.; Mensah, I. Predisposing factors influencing occupational injury among frontline building construction workers in Ghana. *BMC Res. Notes* **2019**, *12*, 1–8. [CrossRef]
14. Danso, F.O.; Adinyira, E.; Manu, P.; Agyekum, K.; Ahadzie, D.K.; Badu, E. The mediating influence of local cultures on the relationship between factors of safety risk perception and Risk-Taking behavioural intention of construction site workers. *Saf. Sci.* **2021**, *145*, 105490. [CrossRef]
15. Adinyira, E.; Manu, P.; Agyekum, K.; Mahamadu, A.-M.; Olomolaiye, P.O. Violent behaviour on construction sites: Structural equation modelling of its impact on unsafe behaviour using partial least squares. *Eng. Constr. Arch. Manag.* **2020**, *27*, 3363–3393. [CrossRef]
16. Osei-Asibey, D.; Ayarkwa, J.; Adinyira, E.; Acheampong, A.; Amoah, P. Roles and Responsibilities of Stakeholders towards Ensuring Health and Safety at Construction Site. *J. Build. Constr. Plan. Res.* **2021**, *9*, 90–114. [CrossRef]
17. Laryea, S. Health and safety on construction sites in Ghana. In Proceedings of the Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors, Paris, France, 2–3 September 2010.
18. Albert, A.; Hallowell, M.R.; Kleiner, B.; Chen, A.; Golparvar-Fard, M. Enhancing construction hazard recognition with high-fidelity augmented virtuality. *J. Constr. Eng. Manag.* **2014**, *1*, 1943–7862. [CrossRef]

19. Al-Sahar, F.; Przegalińska, A.; Krzemiński, M. Risk assessment on the construction site with the use of wearable technologies. *Ain Shams Eng. J.* **2021**, *12*, 3411–3417. [CrossRef]

20. Abas, N.H.; Jalani, A.F.A.; Affandi, H.M. Construction stakeholders' perceptions of occupational safety and health risks in Malaysia. *Int. J. Sustain. Constr. Eng. Technol.* **2020**, *11*, 300–311.

21. Murie, F. Building safety–an international perspective. *Int. J. Occupat. Environ. Health* **2007**, *13*, 5–11. [CrossRef]

22. Kanchana, S.; Sivaprakash, P.; Joseph, S. Studies on labour safety in construction sites. *Sci. World J.* **2015**, *2015*, 590810. [CrossRef]

23. Akinlolu, M.; Haupt, T.C.; Edwards, D.J.; Simpeh, F. A bibliometric review of the status and emerging research trends in construction safety management technologies. *Int. J. Constr. Manag.* **2020**, 1–13. [CrossRef]

24. Mihic, M.; Vukomanovic, M.; Završki, I. Review of previous applications of innovative information technologies in construction health and safety. *Org. Technol. Manag. Constr. Int. J.* **2019**, *11*, 1952–1967.

25. Leviäkangas, P.; Paik, S.M.; Moon, S. Keeping up with the pace of digitization: The case of the Australian construction industry. *Technol. Soc.* **2017**, *50*, 33–43. [CrossRef]

26. Delgado, J.M.D.; Oyedele, L.; Ajayi, A.; Akanbi, L.; Akinade, O.; Bilal, M.; Owolabi, H. Robotics and automated systems in construction: Understanding industry-specific challenges for adoption. *J. Build. Eng.* **2019**, *26*, 100–868. [CrossRef]

27. Haupt, T.C.; Akinlolu, M.; Raliile, M.T. Applications of digital technologies for health and safety management in construction. In Proceedings of the 8th World Construction Symposium, Colombo, Sri Lanka, 8–10 November 2019; pp. 88–97.

28. Lakhiar, M.T.; Abdullah, A.H.; Sohu, S. Application of digital technologies for prevention of accidents in construction of high-rise building projects: A review. *IOP Conf. Ser. Mater. Sci. Eng.* **2021**, *1144*, 012009. [CrossRef]

29. Rowley, J. Designing and using research questionnaires. *Manag. Res. Rev.* **2014**, *37*, 308–330. [CrossRef]

30. Research Optimus. What Is Frequency Analysis? 2021. Available online: https://www.researchoptimus.com/article/frequency-analysis.php (accessed on 17 November 2021).