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Knowledge, Interaction, People & Leadership

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Declaration

All papers in this publication have been through a review process involving initial screening abstracts, review of full papers by at least two referees, reporting of comments to authors, re of papers by authors and re-evaluation of re-submitted papers to ensure quality of conte

TABLE OF CONTENTS

NEA ONNIM NO SUA A, OHU

"He who does not know can know from learning"

This is the Adinkra symbol of knowledge, life-long education and continued quest for knowledge. The Akan people in West Africa believe that the search for knowledge is a life-long process. This is evident from the Akan saying "Nea onnim sua a, ohu; nea odwen se onim dodo no, se ogyae sua a, ketewa no koraa a onim no firi ne nsa" which translates into "He who does not know can become knowledgeable from learning; he who thinks he knows and ceases to continue to learn will stagnate".

FOREWORD

I would like to welcome each participant to the WABER 2021 Conference. Since its inception in 2009, the WABER Conference series has done a great deal to nurture and support researchers, initially in West Africa, also, in other parts of Africa and elsewhere. I would like to thank all delegates for your participation which enables us to keep this Conference going.

The WABER Conference enjoys a positive international reputation and has continued to grow from strength to strength over the past 13 years. For this, I would like to thank our team, keynote speakers and participants over the years for every contribution you have made to the success of this Conference. This year's Conference has an excellent programme, line up of speakers and authors.

I would like to thank and commend the authors of all 72 papers in this Conference proceedings. If the research paper writing process was compared to a marathon, the authors of the 72 papers in this publication would be adjudged as the ones who have endured and finished the race.

We opened the call for papers for this Conference in December 2020 and over 100 abstracts were submitted by authors. However, it is one thing to propose to write a paper, and it is quite another thing to actually write the paper. Therefore, I would like to thank and congratulate all authors who succeeded in completing the process of getting published in this conference proceedings.

It is befitting that we have an excellent range of interesting topics in the 72 papers to be discussed at this conference.

We are honoured to welcome Professor Charles Egbu, Vice Chancellor of Leeds Trinity University, to give us a special opening address.

In the three days of this conference, we will have various plenary presentations by experienced international academics and I would like to thank and welcome each of them below.

Professor Albert Chan
Richard Lorch
Professor Taibat Lawanson
Professor Dato' Sri Ar Dr Asiah Abdul Rahim
Professor George Ofori

In addition to these speakers, we have other interesting sessions on the programme including a special session for doctoral students and supervisors several other experienced speakers addressing various topics that should be of interest to many of us.

I would like to thank all members of the organising team particularly Associate Professor Emmanuel Essah, Dr Yakubu Aminu Dodo and Dr Sam Moveh for their efforts which has helped to organise this Conference successfully. I would also like to thank all of our reviewers particularly Associate Professor Emmanuel Essah and Dr Haruna Moda for the considerable time and effort spent reviewing and checking all papers to ensure a high standard of quality.

The WABER Conference Team always plays an excellent role in the success of our events and I would like to thank and appreciate the contributions of Florence, Sam Boakye, Victor Ayitey and his team, Kwesi Kwofie and Issah Abdul Rahman to the success of this Conference.

I hope you enjoy our first hybrid conference and engage with our exciting speakers on the diverse topics that will be covered over the three days of this Conference.

Sam Laryea
University of the Witwatersrand, Johannesburg, South Africa
Chairman of WABER Conference
August 2021

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PEER REVIEW AND SCIENTIFIC PUBLISHING STATEMENT

9th August 2021

TO WHOM IT MAY CONCERN

The scientific information published in peer-reviewed outlets carries special status, and confers unique responsibilities on editors and authors. We must protect the integrity of the scientific process by publishing only manuscripts that have been properly peer-reviewed by scientific reviewers and confirmed by editors to be of sufficient quality.

I confirm that all papers in the WABER 2021 Conference Proceedings have been through a peer review process involving initial screening of abstracts, review of full papers by at least two referees, reporting of comments to authors, revision of papers by authors, and re-evaluation of re-submitted papers to ensure quality of content.

It is the policy of the West Africa Built Environment Research (WABER) Conference that all papers must go through a systematic peer review process involving examination by at least two referees who are knowledgeable on the subject. A paper is only accepted for publication in the conference proceedings based on the recommendation of the reviewers and decision of the editors.

The names and affiliation of members of the Scientific Committee & Review Panel for WABER 2021 Conference are published in the Conference Proceedings and on our website www.waberconference.com

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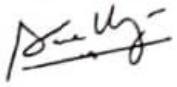

Sam Laryea, PhD
Chairman of WABER Conference

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WABER Conference is very grateful to each the following persons for your contribution to the peer review process. Thank you so much.

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CONFERENCE PAPERS

West Africa Built Environment Research (WABER) Conference
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APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGY FOR THE IMPLEMENTATION OF HEALTH AND SAFETY MEASURES BY CONSTRUCTION FIRMS IN ABUJA, NIGERIAERROR! BOOKMARK NOT DEFINED.

Abdullateef Adewale Shittu[1], Anita Dzikwi Adamu[2], Abel John Tsado[3], Lois Adedamola Arowolo[4] and Shakirat Remilekun Abdulazeez[5]

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The Nigerian construction industry contributes 12% of Gross Domestic Product (GDP) to the nation's economy. In spite of this, studies have shown that health and safety (H&S) measures are poorly implemented by construction firms in Nigeria. Therefore, this study assessed the application of Information and Communication Technology (ICT) on the implementation of H&S measures by construction firms in Abuja, Nigeria. The study employed the use of quantitative research approach with the aid of questionnaire survey to obtain data from 25 construction firms in Abuja that are registered with Federation of Construction Industry (FOCI). Analysis of data was undertaken using Mean Item Score (MIS) and Relative Index (RII). Findings from the study show that H&S measures mostly requiring the use of ICT tools for proper implementation on construction sites which are Creating safety and health regulation and hazard identification, prevention and control (RII = 0.99). Site surveillance technologies (CCTV) is the ICT tools mostly required for monitoring the level of compliance to H&S measures on construction sites (RII = 0.98). The impact of ICT tools on the level of compliance to H&S measures on construction sites is significant (MIS = 4.46). Contractors 'compliance with safety regulation is the most effective strategy for enhancing the safety performance of construction firms on construction sites with the use of ICT tools (MIS = 4.44). It was concluded that use of ICT tools has significant impact on the level of implementation of H&S measures by construction firms. It was recommended that construction firms should set up workable mechanism for effectively implementing the strategies required to enhance the H&S performance of construction firms through the use of ICT tools.

Keywords: construction firms, health and safety measures, information and communication technology

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INTRODUCTION

The construction industry has recently witnessed a paradigm shift from traditional paper-based method of service delivery to electronic information exchange using Information and Communication Technology (ICT), at least in the western world like UK and even in developing countries like Nigeria (Ibironke et al., 2011). It is therefore evident that the adoption of ICT can enhance construction productivity and improve communications for effective decision-making and coordination among construction participants and reduce H&S risks on construction sites if it can be applied. Interestingly, ICT has been embraced in every sector of the economy including some aspects of the construction sector in ensuring that various tasks are carried out more efficiently and effectively. Unfortunately, in the domain of H&S, the use of ICT has not been adequately explored especially in the areas of H&S site inspection and supervision in order to ensure strict compliance (Ahmad, 2019).

Studies in H&S have only been able to discover low level implementation and compliance to H&S measures on construction sites and suggested strategies for improvement (Shittu et al., 2016; Shittu et al., 2017; Eze et al., 2018; Ahmad, 2019). These strategies have not been able to effectively reverse the trend significantly. The use of ICT to facilitate the level of compliance to the H&S measures has therefore not been addressed. In view of the fact that ICT is comprised of tools that use Artificial Intelligence (AI) to carry out tasks more safely, efficiently and effectively, it is a better option worthy of being adopted for enhancing the level of compliance to H&S on sites. This is due to the fact that the use of ICT tools is better for the monitoring and evaluation of implementation of H&S measures on construction sites as compared with the conventional approach which had been suggested by previous studies and have failed to yield the desired outcome. On account of this, Pamulu & Bhuta (2004) reported that technological advancement can no longer be viewed as an enhancement of traditional business procedures but rather as an innovation agent that enables new and different alternatives to operation of business organisation. It is on this premise that this study assessed the application of ICT for implementation of H&S measures by construction firms in Abuja. Therefore, in the context of this work application of ICT means the use of ICT for the implementation of H&S measures on sites.

In view of this background, this study addressed the problem of lack of proper implementation of H&S measures on construction sites which leads to increase in the rates of accidents, injuries and fatalities on sites. The resultant effect is poor H&S performance of construction firms in terms of cost due to compensation to injured workers. It is therefore imperative to assess the application of ICT on the implementation of H&S measures by construction firms in Nigeria using Abuja as the study area. Abuja was chosen as the study area because a reasonable number of construction activities take place in Abuja because it experiences rapid population increase and new developmental projects daily as a result of rapid urbanisation and rural-urban migration since it is the capital city of Nigeria (Kadiri et al., 2014).

In order to proffer suggestions towards addressing the research problem identified, the study aimed at assessing the application of ICT for implementation

of H&S measures by construction firms in Abuja with a view to enhancing the safety performance of construction firms. The following objectives were therefore pursued in order to achieve the aim of the study:

1. To identify and examine the H&S measures mostly requiring the use of ICT tools for proper implementation on construction sites.
2. To identify the ICT tools mostly required for monitoring the level of compliance to H&S measures on construction sites in Abuja.
3. To determine the impact of the identified ICT tools on the level of compliance to H&S measures on construction sites.
4. To propose strategies for enhancing the safety performance of construction firms through the use of ICT tools for monitoring and evaluation of compliance to H&S measures on construction sites.

REVIEW OF RELATED LITERATURE

H&S measures requiring the use of ICT tools for proper implementation on construction sites

Construction H&S measures are best site practices that should be implemented towards ensuring the health, safety and welfare of individuals involved in work employment. Idoro (2011) revealed that all categories of contractors working in the Nigerian construction industry do not perform better than one another as regards H&S and therefore calls on stakeholders within the industry to develop and enhance their H&S performance. Hence, the use of ICT can increase the level of implementation of H&S measures by workers on construction sites, thereby improving the safety performance of construction firms in the Nigerian construction industry.

In order to achieve these past studies have identified the H&S measures requiring the use of ICT tools to include: Creating safety and health regulation; Identify hazard; Worker safety training; Design for safety; Safety planning (job hazard analysis and planning); Accident investigation; and Facility and maintenance phase safety; Assess and evaluation risk; Decide precautions; Record findings; and Review and update (Rajendran & Clarke, 2011; Charehzehi & Ahankoob, 2012; OSHA, 2016; Lekan & Charles, 2017; Webb & Langar, 2019)

ICT tools required for monitoring level of compliance to H&S measures on construction sites

AHT Group (2014), Bromley et al. (2014) and Zhang et al. (2017) reported that Remote Sensing (RS), in combination with modern Information and Communication Technology (ICT) can be used to effectively monitor the level of compliance of workers on site at a low cost and with time saving in construction. These RS tools are identified as: Unmanned Aerial Vehicles (UAV); GPS navigation system; Mobile telecommunications interception equipment; Intrusion software; IP Network Surveillance; Monitoring; Lawful Interception (LI) systems; Data retention systems; Digital forensics; Probes; Deep Packet Inspection (DPI); Radio frequency identification (RFID), WLAN, UWB, Zigbee; Ultrasound Modelling and visualization (3D-CAD, 4D-CAD); Electronic document management system (EDMS); Site

surveillance technologies (CCTV); Video conferencing; Project specific websites (Extranets); Electronic tendering; Electronic purchasing; Tele conferencing; and barcodes. The contributions of According to Mohan & Varghese (2019) revealed that with the help of Artificial Intelligence (AI), safety in construction sites can be monitored at ease. An example of this is the AI Enabled Building Information Modelling (BIM).

Impact of ICT Tools on the level of compliance to H&S measures on construction sites

According to Idoro (2011), best site practices on H&S protect co-workers, employers, customers, suppliers and members of the public influence by the workplace environment. In addition to this, Ikechukwu et al. (2011) reported that different government and private boards within have made regulations and code of conduct in consideration of the importance and need for efficiency and the effective use of ICT. The evolution of technology which has led to the invention and development of telephones, computers, electronic and electrical equipment are all fundamental in the present day construction industry. The value is very important as construction projects involve a large flow of construction documentary information linking project participants during both design and construction phases.

According to Eastman et al. (2011), Cheng & Teizer (2013), Tahir et al. (2015), Azmy & Zain (2016), Park et al. (2017), Zhang et al. (2017), Uchenna et al. (2018) and Webb & Langar (2019) in an effort to improve construction processes, the application of innovative wireless communication technology such as the RFID technology can be employed to minimise accident and improve H&S on construction sites. In a similar view, Alomari et al. (2017) reported that an added benefit of BIM as an ICT tool is ease of communication and collaboration among stakeholders.

Strategies for enhancing safety performance of construction firms through the use of ICT tools

The major strategies for enhancing the safety performance of construction firms, as identified by past studies (Sawacha et al., 1999; Teo et al., 2005), are that project managers should focus more attention to provision of sufficient company policies, safe procedures, positive attitudes of construction personnel, high efficiency in management commitment and adequate safety knowledge and training of staff. In addition, one of the main elements for improving safety performance in construction projects identified by Charehzehi & Ahankoob (2012) and Tahir et al. (2015) are: Risk Analysis in the Design Stage; Training Strategy; Reward Policy; Management Commitment to the Implementation of Safety Culture; Contractor Comply with Safety Regulation; Providing Safe Equipment and Tools; Personnel Selection; Take a Responsibility to Report Near-Miss Accident; and Creating safety and health regulation.

CONCEPTUAL FRAMEWORK FOR THE STUDY

Studies on H&S management have designed various implementable framework for improving safety performance of workers and employers in construction projects. Some of the ones applicable to this study are: H&S performance measurement

model (Health and Safety Executive, HSE, 2001); Construction competency and H&S performance framework (Dingatag et al., 2006); and Construction safety implementation framework (Ahmed & Abid, 2013). It is based on these theoretical frameworks that this study's conceptual framework was developed as presented in Figure 1.

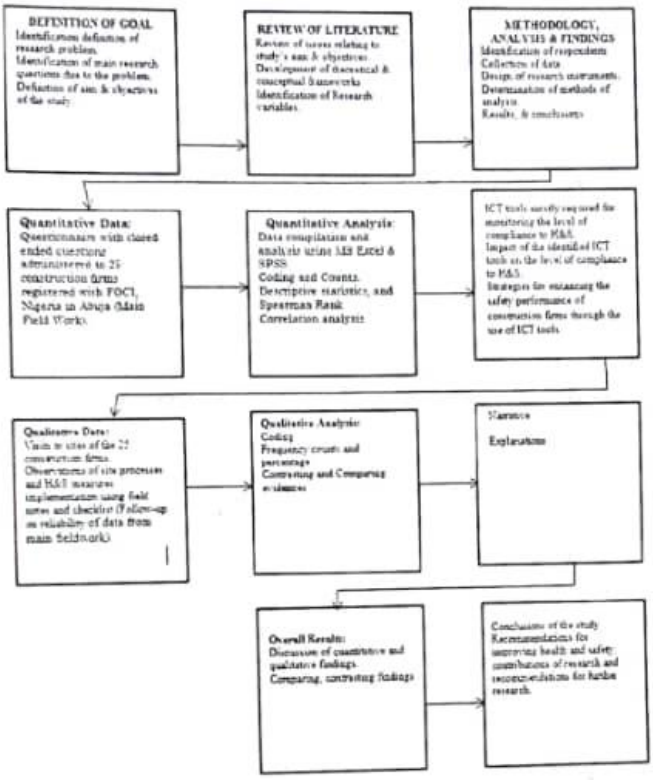

Figure 1: Conceptual framework for the study

RESEARCH METHODOLOGY

The quantitative research approach was adopted in this study. The use of structured questionnaire was employed for data collection in order to achieve the study's objectives. The data collected were analyzed with the use of Relative Importance Index (RII) and Mean Item Score (MIS). MIS and RII were employed because it is the perception of safety officers that was sought with the questionnaire.

The population for the study is made up of construction firms registered with Federation of Construction Industry (FOCI) with Abuja's business address. FOCI was incorporated in 1954 and it is a mixture of indigenous, indigenized and foreign enterprises (FOCI, 2012). It is the umbrella of construction companies in Nigeria. Its membership is comprised of both construction active (full time) and non-

construction active (part time) members. FOCI has more than 100 members. Only about 84 of these are full time members which are construction firms across Nigeria. Of this 84, only 25 are active or domicile in Abuja (FOCI Directory, 2019). Since the study area is Abuja, then the 25 construction firms registered with FOCI and based in Abuja were considered for the study. The research population size is therefore 25.

The list containing information about the construction firms registered with FOCI in Abuja constitutes the study's sampling frame. This gives the features of the construction firms for easy access to aid the data collection process for the study. The sample size for the study is the same as the population size (that is 25). Therefore, all the 25 construction firms registered by FOCI in Abuja were considered for data collection. In view of the fact that the population size is not large, the study took a census of the whole 25 construction firms for data collection. This is in line with the assertion of Watson (2001) that if the population size is small (200 or less), then it is preferable to take a census of the total population.

The questionnaire (designed on a five-point Likert's Scale format) is comprised of five sections. The first section addressed issues relating to the profile of respondents. The last four sections addressed issues relating to the research objectives respectively. For the site observation, the use of a checklist form was employed to record what was about the firms 'provision of pro-active and reactive H&S measures on site as detailed out in the results section. The site observation took an average of 5 days for each construction firm. Twenty – five copies of questionnaire were administered (one copy to the safety officer of each firm). All the questionnaire copies distributed were returned and useful for analysis.

In order to validate the research instrument used, a reliability test was carried out on the data collected. The result of the reliability test shows a Cronbach's Alpha of 0.848 which was very high and close to 1.000. The Cronbach's Alpha based on standardized items is 0.849 and is of a higher value and closer to 1.000. This shows that the research data are reliable and hence the research instrument is valid. The decision rule adopted for the RII and MIS are summarised in Table 1.

Table 1: Decision rule for RII and MIS analyses

Scale	Cut-Off Point		Interpretation		
	RII	*MIS*	*Level of Importance*	*Level of Significance*	*Level of Effectiveness*
5	0.81 - 1.00	4.51 - 5.00	Very Important	Very Significant	Very Effective
4	0.61 - 0.80	3.51 - 4.50	Important	Significant	Effective
3	0.41 - 0.60	2.51 - 3.50	Fairly Important	Fairly Significant	Fairly Effective
2	0.21 - 0.40	1.51 - 2.50	Less Important	Less Significant	Less Effective
1	0.00 - 0.20	1.00 - 1.50	Least Important	Least Significant	Least Effective

Source: Adapted and Modified from Shittu et al. (2015b)

The study chose 3.51 – 5.00 as the cut-off point for the important H&S measures due to the fact that H&S, being a crucial issue to the well-being of workers and

success of a project, requires best practices in order to bring about improved performance. Based on the scale used (1 - 5), best H&S measures should be far above average. In addition, in the study of Agumba & Haupt (2014) the mean score of the identified important H&S practices ranged between 3.80 and 4.60. Within the same context, the studies of Eze et al. (2016), Shittu et al. (2017) and Shittu et al. (2020) also used a cut-off point of 3.50 – 5.00 for the important H&S measures on construction site. This therefore justifies the choice of 3.50 – 5.00, used in this study as the cut-off point for the important H&S measures requiring the use of ICT tools for proper implementation, significant impacts of ICT tools on H&S measures implementation, and effective strategies for improving the implementation level of H&S measures on construction sites.

RESULTS AND DISCUSSION

Results and discussion on H&S measures mostly requiring the use of ICT tools for proper implementation on construction sites

Table 2 presents the result of the H&S measures mostly requiring the use of ICT tools for proper implementation on construction sites.

Table 2: Results of H&S measures mostly requiring the use of ICT tools for proper implementation on construction sites in Abuja

Code	H&S Measures	RII	Rank	Decision
C1	Creating safety and health regulation	0.99	1st	Very Important
C2	Hazard Identification	0.98	2nd	Very Important
C3	Hazard prevention and control	0.98	2nd	Very Important
C4	Facility and maintenance phase safety	0.97	4th	Very Important
C5	Risk Assessment and Evaluation	0.96	5th	Very Important
C6	Education and training	0.96	5th	Very Important
C7	Precautions Decision Making	0.94	7th	Very Important
C8	Management leadership	0.94	7th	Very Important
C9	Communication and coordination for employers on multiemployer worksites	0.94	7th	Very Important
C10	Design for safety	0.94	7th	Very Important
C11	Record findings	0.92	11th	Very Important
C12	Review and Update	0.92	11th	Very Important
C13	Accident investigation, Facility and maintenance phase safety	0.90	13th	Very Important
C14	Worker participation	0.86	14th	Very Important
C15	Program evaluation and improvement	0.85	15th	Very Important
	Average RII	*0.94*		*Very Important*

Table 2 reveals fifteen (15) identified H&S measures mostly requiring the use of ICT tools for proper implementation on construction sites which are all very important with MIS ranging from 0.85 – 0.99. The most important H&S measure is Creating safety and health regulation (MIS = 0.99), while the least important one is Program evaluation and improvement (MIS = 0.88). The average MIS value shown is 0.94. This also reveals that all the identified H&S measures mostly requiring the use of ICT tools for proper implementation on construction sites are very important. This is in line with the finding of Charehzehi & Ahankoob (2012) where it was revealed that these H&S measures are guidelines to assist the team members in the construction industry to manage their safety in their workplaces with the use of ICT tools. OSHA (2016) also identified these measures as good H&S practices where the use of ICT tools are required in support of the finding of this study. Rajendran & Clarke (2011) also identified most of these H&S measures as vital areas in which BIM can prove useful. Other previous studies which support the finding of this study are Lekan & Charles (2017); Amusan et al. (2018); and Webb & Langar (2019). All these studies emphasize the need to for stakeholders within the construction industry to develop and enhance their H&S performance (with respect to these H&S measures) through the use of ICT tools. Hence, the use of ICT can increase the level of implementation of H&S measures by workers on construction sites, thereby improving the safety performance of construction firms in the Nigerian construction industry.

Results and discussion on ICT tools mostly required for monitoring the level of compliance to H&S measures on construction sites in Abuja

The use of Relative Importance Index (RII) was employed to examine the ICT tools mostly required for monitoring the level of compliance to H&S measures on construction sites in Abuja. The result of the analysis is presented in Table 3.

Table 3 shows the 18 ICT tools mostly required for monitoring the level of compliance to H&S measures on construction sites. It was shown that Site surveillance technologies (CCTV), Remote Sensing (RS) standard cellular phones, smart phones or tablets, Mobile Radio Systems, Electronic document management system (EDMS), and Email and short message services (SMS) are the most important ICT tools with RII values of 0.98, 0.96, 0.94, 0.92 and 0.90 respectively. Five (%) other ICT tools are also very important. These are Radio Frequency Identification Device (RFID), GPS (Global Positioning System), Modelling and visualization (3D-CAD, 4D-CAD), Ultra-wideband (UWB), and 3D and 4D visualization technology with RII values of 0.89, 0.86, 0.85, 0.84 and 0.83 respectively. The remaining eight (8) ICT tools (in descending order) are also important with RII values ranging from 0.80 – 0.62. On the average, all the identified ICT tools are required for monitoring the level of compliance to H&S measures on construction sites in Abuja are very important with average RII value of 0.83. The finding here agrees with the finding from the study of AHT Group (2014) which reported that RS, in combination with modern ICT, provides an excellent means for the collection and analysis of spatial data on "real world phenomena", making these tools particularly valuable for project planning and monitoring in the development cooperation context. The finding of this study is also supported by that of Tahir et al. (2015) where it was stated that that wireless sensing technology, such as the RFID, can be used to examine H&S of individuals and equipment on site. This is because RFID tags transmit wireless data to a system with RFID reader which in turn develops a

warning system that alerts construction workers of potential threats. Other studies such as Bromley et al. (2014); Azmy & Zain (2016); Zhang et al. (2017); and Mohan & Varghese (2019) also confirms the importance of these ICT tools to H&S compliance. It is therefore important to emphasize that for a safe and healthy construction workplace, the use of ICT tools for monitoring compliance to H&S rules is important.

Table 3: Results of ICT tools mostly required for monitoring the level of compliance to H&S measures on construction sites in Abuja

Code	ICT Tools	RII	Rank	Decision
B1	Site surveillance technologies (CCTV)	0.98	1st	Very Important
B2	Remote Sensing (RS) standard cellular phones, smart phones or tablets.	0.96	2nd	Very Important
B3	Mobile Radio Systems	0.94	3rd	Very Important
B4	Electronic document management system (EDMS)	0.92	4th	Very Important
B5	Email and short message services (SMS)	0.90	5th	Very Important
B6	Radio Frequency Identification Device (RFID)	0.89	6th	Very Important
B7	GPS (Global Positioning System)	0.86	7th	Very Important
B8	Modelling and visualization (3D-CAD, 4D-CAD)	0.85	8th	Very Important
B9	Ultra-wideband (UWB)	0.84	9th	Very Important
B10	3D and 4D visualization technology	0.83	10th	Very Important
B11	Video conferencing	0.80	11th	Important
B12	IP Network Surveillance	0.78	12th	Important
B13	Wireless local area network (WLAN)	0.78	12th	Important
B14	Zigbee (two-way wireless communication technique)	0.78	12th	Important
B15	Ultrasound positioning system	0.77	15th	Important
B16	Artificial Intelligence Enabled BIM	0.72	16th	Important
B17	Unmanned Aerial Vehicles (UAV)	0.70	17th	Important
B18	Real-Time tracking system, RFIDs, automation and remote sensing technology	0.62	18th	Important
	Average RII	*0.83*		*Very Important*

Results and discussion on impact of ICT tools on the level of compliance to H&S measures on construction sites

Table 4 gives a summary of the MIS ranking results of the impact of ICT tools on the level of compliance to H&S measures on construction sites in Abuja based on respondents 'perception.

Table 4: Results of impact of ICT tools on the level of compliance to H&S measures on construction sites in Abuja

Code	Impact of ICT Tools on the Level of Compliance to H&S Measures	MIS	Rank	Decision
D1	Providing a high level of safety training for employees.	4.80	1st	Very Significant
D2	Avoid the direct and indirect costs of worker injuries and illnesses, and promotes a positive work environment.	4.80	1st	Very Significant
D3	Enable management to avoid accidents and eliminate H&S hazards so as to reduce the difficulty of employees as well as minimising their loss.	4.76	3rd	Very Significant
D4	Reduce lots of fatalities and improve productivity by providing solutions and remedy to H&S problems and also providing workers on site with potential occurrence of existing danger on construction site.	4.76	3rd	Very Significant
D5	Aid operational improvement through communication of construction information for effective decision-making and coordination.	4.72	5th	Very Significant
D6	BIM tools allow project stakeholders to share information about sequencing, physical site topography, and clash detection; improve communication among the project stakeholders; and identify potential locations and times of hazardous and non-hazardous construction project activities.	4.68	6th	Very Significant
D7	The virtual planning of work sequencing to incorporate necessary safety equipment and measures.	4.68	6th	Very Significant
D8	Create a detailed Environmental Safety and Health (ES and H) plan to be dispersed among all workers.	4.68	6th	Very Significant
D9	Providing new methods in construction and planning such as Building Information Modeling methodology and IBS technology.	4.64	9th	Very Significant
D10	Increase the level of implementation of H&S measures by workers on construction sites.	4.60	10th	Very Significant
D11	Verification that all structures can be constructed safely and productively.	4.60	10th	Very Significant
D12	Integration of client, designer and contractor in design stage to eliminate adversarial nature and preventing conflict in early stage of projects which lead to mitigate the destructive risk during building process.	4.56	12th	Very Significant
D13	Offer opportunities to enhance communication between participants in construction projects and to enable more effective and efficient communication.	4.52	13th	Very Significant
D14	Decrease time for data processing and communicating information.	4.52	13th	Very Significant
D15	Improvement of site condition	4.52	13th	Very Significant
D16	Avoiding the use of outdated equipment and plants during construction stages.	4.52	13th	Very Significant
D17	Harnessing the capability to improve safety training as workers can "walk through" a job site or building increases understanding and helps prepare for the sequencing of tasks.	4.32	18th	Significant
D18	Obtain timely information regarding work progress to manage workflows.	4.16	19th	Significant
D19	Reduce the need for co-workers to be located in the same venue.	4.12	20th	Significant
D20	Protect co-workers, employers, customers, suppliers and members of the public influence by the workplace environment.	3.88	21st	Significant
D21	Intelligence of sensor-based technology helps construct an interactive management platform, which is the integration of hardware and software for data processing, significantly improving the construction site monitoring capacity and providing guarantees for construction safety.	3.68	22nd	Significant
D22	Capacity building in Remote Sensing (RS) and ICT is key to attain sustainability by ensuring an adequate and professional use of these techniques in the post-project period.	3.64	23rd	Significant
D23	Have shaped substantially the mode of workers' interaction, business process, entertainment, learning and implementation attitude.	4.46		Significant
	Average MIS			

Table 4 revealed 23 main impacts of ICT tools on the level of compliance to H&S measures on construction sites. The first seventeen (17) impacts are very significant. These range from Providing a high level of safety training for employees (MIS = 4.80) to Harnessing the capability to improve safety training as workers can "walk through" a job site or building increases understanding and helps prepare for the sequencing of tasks (MIS = 4.52). The most significant impacts of ICT tools on the level of compliance to H&S measures on construction sites are Providing a high level of safety training for employees and Avoid the direct and indirect costs of worker injuries and illnesses, and promotes a positive work environment (MIS = 4.80 respectively). The remaining six impacts are also significant. These range from Obtain timely information regarding work progress to manage workflows (MIS = 4.32) to Have shaped substantially the mode of workers 'interaction, business process, entertainment, learning and implementation attitude (MIS = 3.64). On the average, all the identified impacts of ICT tools on the level of compliance to H&S measures on construction sites are significant (average MIS = 4.46). The finding of Ikechukwu et al. (2011) supports this study's finding by emphasizing that the rapid evolution of ICT offers opportunities to enhance communication between participants in construction projects and to enable more effective and efficient communication. Webb & Langar (2019) also reported that the onus of safety management and site accident mitigation is shifting with the development of technology by incorporating BIM into project planning in support of this study. Therefore, the use of the intelligence of sensor-based technology helps construct an interactive management platform, which is the integration of hardware and software for data processing, significantly improving the construction site monitoring capacity and providing guarantees for construction safety.

Results and discussion on the strategies for enhancing the safety performance of construction firms on construction sites

The result of the MIS analysis carried out to rank the perception of respondents on the identified strategies for enhancing the safety performance of construction firms is presented in Table 5.

It Is shown from Table 5 that ten (10) out of the twelve (12) identified strategies for enhancing the safety performance of construction firms on construction sites in Abuja are effective. These range from Contractor Comply with Safety Regulation (MIS = 4/44) to Proper implementation of fatalities and incidence reporting/investigation with the application of innovative communication technology such as the RFID technology (MIS = 3.64). The two least ranked strategies are fairly effective. These are Development of Framework for Enhancing Strategies for Implementing Training and Re-training for Workers on Compliance to H&S (MIS = 3.44) and Introduction of Risk Analysis in the Design Stage (MIS = 3.20). On the average, all the identified strategies for enhancing the safety performance of construction firms on construction sites in Abuja are effective (average MIS = 3.96). The studies of Charehzehi & Ahankoob (2012) and Tahir et al. (2015) are in line with the finding from this analysis because these past studies emphasize that these strategies can improve H&S on site and thus minimising accidents occurrence such as accident due to heavy equipment's and tools and also collision between workers and heavy operating equipment; which are considered as one of the most occurred on site. It is therefore important to note that for

construction firms to execute projects safely on construction sites, these effective strategies must be implemented to the latter.

Table 5: Result of strategies for enhancing the safety performance of construction firms on construction sites in Abuja

Code	Strategies for Enhancing the Safety Performance	MIS	Rank	Decision
E1	Contractor Comply with Safety Regulation	4.44	1st	Effective
E2	Site Personnel Selection	4.36	2nd	Effective
E3	Creating safety and health regulation.	4.32	3rd	Effective
E4	Hiring contractors who have proved a record of good safety performance during the processes of qualifying contractors for bidding work and ranking contractors for a contract award.	4.16	4th	Effective
E5	Providing Safe Equipment and Tools	4.16	4th	Effective
E6	Establishing a Reward Policy.	4.08	6th	Effective
E7	Management Commitment to the Implementation of Safety Culture	4.08	6th	Effective
E8	Establishment of effective company policies that will promote safe procedures, positive attitudes of construction personnel, high efficiency in management commitment and adequate safety knowledge and training of staff.	3.88	8th	Effective
E9	Take a Responsibility to Report Near-Miss Accident.	3.80	9th	Effective
E10	Proper implementation of fatalities and incidence reporting/investigation with the application of innovative communication technology such as the radio frequency identification (RFID) technology.	3.64	10th	Effective
E11	Development of Framework for Enhancing Strategies for Implementing Training and Re-training for Workers on Compliance to H&S	3.44	11th	Fairly Effective
E12	Introduction of Risk Analysis in the Design Stage	3.20	12th	Fairly Effective
	Average MIS	***3.96***		***Effective***

CONCLUSION AND RECOMMENDATIONS

The study revealed that the identified ICT tools required for monitoring the level of compliance to H&S measures on construction sites in Abuja are very important. The identified H&S measures mostly requiring the use of ICT tools for proper implementation on construction sites are very important. The most significant impacts of ICT tools on the level of compliance to H&S measures on construction sites are: providing a high level of safety training for employees; and avoiding the direct and indirect costs of worker injuries and illnesses, and promotes a positive work environment. In addition, all the identified impacts of ICT tools on the level of compliance to H&S measures on construction sites are significant. The identified

strategies for enhancing the safety performance of construction firms on construction sites in Abuja are effective. It can therefore be concluded that the application of ICT tools has a significant impact on the level of implementation of H&S measures by construction firms in Abuja. There is therefore the need for construction firms to embrace the use of ICT tools to monitor the implementation of H&S measures on site in order to improve the level of compliance to H&S measures and hence improve the safety performance/practices of employees and construction firms.

In view of the findings and conclusions of this study, the following recommendations were made:

1. The management of construction firms should invest in training their safety officers or anybody so assigned H&S responsibility on the use and application of Remotes Sensing tools in combination with modern ICT in order to be able to effectively plan and monitor site activities in a safety and health compliant manner. This will bring about improved H&S compliance of workers on site.

2. Regular and periodic education and training programmes should be used to communicate the importance of the identified H&S measures mostly requiring the use of ICT tools for proper implementation on construction sites to workers. This will build up positive attitude of employers and employees towards H&S practices on site and hence the improvement of H&S measures implementation level.

3. Construction firms should facilitate H&S communication by using the intelligence of sensor-based technology in order to construct an interactive management platform, which is the integration of hardware and software for data processing, significantly improving the construction site monitoring capacity and providing guarantees for construction safety. This is because the study has established that there exists a positive relationship between the use of ICT tools and level of implementing H&S measures on construction sites.

4. All the afore mentioned recommendations should be harmonised in order to put up a workable mechanism for the effective implementation of the identified strategies for enhancing the safety performance of construction firms on construction sites in Abuja. This is because the study found that these strategies are effective.

The findings of this study has contributed to the body of knowledge in the built environment in various ways. The study revealed that for a safe and healthy construction workplace, the use of ICT tools for monitoring compliance to H&S rules is important (average RII = 0.83). The study also showed that the use of ICT tools can increase the level of implementation of H&S measures by workers on construction sites (average RII = 0.94). It was also revealed that the impacts of ICT tools on the level of compliance to H&S measures on construction sites are significant (average MIS = 4.46).

In view of the limitations of this study, some areas have been suggested for further studies. Researchers can study the effect of safety officers 'leadership quality on the adoption of ICT tools and Artificial Intelligence for enhancing the level of

implementation of safety measures on construction sites. The effect of organisational characteristics on the on the application of ICT tools and Artificial Intelligence on the implementation of safety measures on construction sites can also be studied.

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INDEX OF AUTHORS

INDEX OF KEYWORDS