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Assessment of the Benefits of Smart Wearable Devices for Construction Health and Safety in Lagos State, Nigeria

A. Moses Adejumo, Ayodeji Emmanuel Oke
Department of Quantity Surveying, Federal University of Technology Akure, Nigeria
Department of Quantity Surveying, Federal University of Technology Akure, Nigeria

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ABSTRACT
Construction health and safety has faced setback as a result of a number of circumstances, and the rate of building site accidents as well as the low productivity turnout on an annual basis are rising. Modern technology has made every aspect of human endeavor susceptible to the application of technological tools for maximum performance and increased production that satisfy client expectations. The purpose of this study is to assess the benefits of smart wearable devices for construction health and safety in order to encourage its adoption for construction safety and productivity. The research adopted a quantitative research method and data were collected from forty (40) on-going corporate building projects within Lagos state, Nigeria using a purposive sampling technique with a well-structured questionnaire of 120 distributed across the selected site and 102 were retrieved which is amounted to 85% of the total respondents. The collected data were analyzed using mean item score, standard deviation and Kruskal-Wallis test to examine the significant influence between them. It was found that the devices are mostly beneficial in term of 'Productivity increase, health and wellness of human, connectivity and efficiency', 'aiding the effective performance of employees and provide necessary help against potential danger within the workplace setting', 'Enhance effective documentations among others and there was no significant influence that exist. It was recommended that the construction stakeholders and the government should pay attention to the benefits and encourage its usage in the construction industry.

KEYWORDS: Construction, health and safety, smart wearables devices, benefits, stakeholders

I. INTRODUCTION

The construction sector contributes to the Gross Domestic Product (GDP), which is a crucial component of the economy of many nations, especially those that are developing. Due to the industry's propensity for risky operations, which frequently result in high accident rates, low productivity, and health issues for employees, practitioners, end users, and the general public (Kadiriet al, 2014).

While numerous researchers have provided their theories regarding the causes of the recurrence of these events in the industry, it was observed that the lack of adequate database storage made it difficult to control the frequency of accidents. Others attribute low productivity to issues with worker health, quality assurance, the environment at the job site, insufficient information flow, theft, and unfavorable weather, among other things (Abubakar &Abdulateef, 2015; Rojas &Aramvareekul, 2003; Thomas et al., 2002; Adrian, 2002).

Obviously, poorly managed construction resources and events over the years have an impact on health and safety of workers on construction sites today. It should be noted, however, that the advantages of workplace health and safety cannot be understated, as these include increased productivity, lower accident rate, creation of a safe working environment among others (Teizeret al., 2007; Al Haadir&Panuwatwanich, 2011; Rowlinson, 2003; Othman et al., 2018). The need to maintain sanctity on construction health and safety demand the attention of construction stakeholders to the use of smart wearables due to its underlaying benefits.

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II. SMART WEARABLES AND ITS BENEFITS

Global digitization has sparked the creation of smart wearable technology that benefits all facets of human endeavors. Some of these gadgets, including wearable cameras, smart shirts, smart gloves, smart wristwatches, smart wristbands, help with keeping track of activities and events before or while they happen (White et al., 2002). Others are smart boot, smart helmet, headbands, necklaces, wearable chest belt, wearable digital activity tracker, smart ring, smart shoes, smart glove, wearable ear buds etc. (Lopez et al., 2020).

These devices are sensor configured that are worn on human body for intelligent purposes due to its smart and wearability features (Fernández-Caramés& Fraga-Lamas, 2018). It possesses integrated framework which gives room for data collections, internet connectivity to a cloud-based server for data sending and storage, embedded learning machine and analytics algorithms that function for analyzing of data for diagnosis. The device has gain popularity in health sector especially in tracking physiological sign such as heart rate, blood pressure, oxygen saturation and body temperature (Raja et al. 2019; Windmiller and Wang, 2017).

Meanwhile, it is on record that developed countries of the world have maximized the opportunities of these devices in averting dangers, potential hazards and improve productivity on construction sites due to its benefits established from the development of smart bands and helmets for monitoring employees' health and safety on the job site, together with cell phones that facilitate communication between the two components (Mehata et al., 2019) and the creation of a Sub-1 GHz sensor network for tracking construction worker falls in Korea using a gyroscope and an accelerometer (Park et al., 2019).

The application of these devices also aids in monitoring surrounding environment and gathered the necessary information within the surrounding, process it and output them for better understanding of the users or workers, (Fernández-Caramés& Fraga-Lamas,2018; Awolusiet al.,2019).Also, it helps effective performance of employees and provide necessary help against potential danger within the workplace setting (Khakurel, Melkas, and Porras, 2018) because ahealthy employee will improve an organization performance and productivity through commitment and positive mindset to job with low absenteeism (Giddens, Leidner& Gonzalez, 2017). Its application in the construction industry at the pre-construction stage especially in survey work will also aid technician's support during fieldwork with the use of helmet camcorder and the recorded video can be transfer to central location (AL-Sahar et al., 2021).

Others have also view that its application aid the prevention and reduction of workers expose to potential hazards leading to improvement in working condition and safety performance (Azeez &Gambatese, 2018), assisting work scheduling, reduce cost and improve quality of work throughout the project life-cycle (Ozorhon& Oral, 2016), increase productivity, health and wellness of human, connectivity and efficiency (PricewaterhouseCoopers, 2014), location tracking and proximity detection (Awolusiet al., 2018). This study therefore aims to assess the benefits of smart wearables for construction health and safety in Nigeria with a view to encourage its adoption for construction site safety and productivity.

III. METHODOLOGY

The research adopted a quantitative methods of data collection to seek respondents' opinion on subject matter based on experience on construction site with the use of well-structured questionnaire distributed directly to stakeholders working directly on selected forty (40) on-going corporate construction project in Lagos state, Nigeria. Lagos state was considered as the study area because of the is one of the major commercial capital and hub of construction activities in Nigeria (Babatunde et al., 2010), rate of building failure, loss of lives and low construction productivity are on the increase (Oduola, 2021; Kadiriet al, 2014).

The stakeholders captured are client, contractor, site workers and health and safety officer on these construction project whom were asked to rate the benefits derived from the literatures on a likert scale of 5 ranging from Very high = 5, to very low = 1, the questionnaire captured the respondent's information and their opinion on the research topic. The study adopted purposive sampling of non-probabilistic sampling technique; the sampling techniques was adopted because it helps accessing key respondents in the field of research that will help in providing information-rich that are needed for particular research (Suri, 2011). It is therefore fit for the study due to the characteristics and peculiarity of the respondents needed for this research.Although this study has some limitations, they include the need for permission from top management at each site to access it, the busy schedules of both skilled and unskilled workers which prevent them from having enough time to interact with visitors, and the

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challenge of finding these corporate sites within the study area.

The data retrieved were analyzed using mean item score, standard deviation and Kruskal Wallis test, the Kruskal Wallis test was necessary so as to determine the significant influence of the respondent's years of experience to benefits of the devices and the result were presented in tables.

IV. DATA PRESENTATION

1.1 Response Rates of Questionnaire Survey

A total of one hundred and twenty (120) copies of the questionnaire survey was administered to the construction stakeholders working on the construction sites. However, one hundred and two (102) copies of the questionnaire survey were retrieved and deemed useful for analysis. The retrieval rate stood at 85% and was adequate for analysis since it exceeded the stated percentage of Moser and Kalton (1999), that a survey's response rate is biased if it is less than 30%.

Table 1: Response Rates of Questionnaire Survey

Professionals	Number Distributed	Number Retrieved
Construction Stakeholders	120	102

The Cronbach alpha test was used to establish the internal coherent and consistency of the survey instrument showed that the questionnaire survey had alpha value of 0.891 which was above the prescribed value of 0.7 (Pallant& Manual, 2007).

4.2 Respondents' Information

The respondent's information as shown in table 2 revealed that the respondents have the required education and years of experience to perfectly fill the questionnaire survey and supply accurate information to measure and provide inference for the study.

Table 2: General information of the respondents

Variables	Classification	Frequency	Percentage
Respondent position on site	Client	22	21.6
	Contractor	23	22.5
	Site Worker	39	38.2
	Health Safety Officer	14	13.7
	Others	4	3.9
	Total	**102**	**100.0**
Academic qualification	ND	20	19.6
	HND	35	34.3
	B.SC/B.TECH	32	31.4
	M.SC/M.TECH	14	13.7
	PHD	1	1.0
	Total	**102**	**100.0**
Years of professional experience	Less than 5 years	31	30.4
	6 to 10 years	30	29.4
	11 to 15 years	28	27.5
	16 to 20 Years	11	10.8
	Above 21 years	2	2.0
	Total	**102**	**100.0**

4.3 Stakeholders' knowledge on smart wearable devices

Table 3 shows the awareness of the respondents on smart wearable devices for construction health and safety. The result indicates that 74(72.5%) respondents are aware of smart wearables technology, 26(25.5%) respondents are not aware, while 2(2.0%) are not sure of its awareness. furthermore, 47(46.1%) respondents are aware that smart wearable deviceswork with internet connectivity on construction project sites, 38(37.3%) respondents are not aware while 17 (16.7%) respondents are not sure of this awareness. This result shows that the respondents are

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knowledgeable of smart wearable devices and its internet connectivity.

Table 3: Awareness of smart wearable devices for construction health and safety

Question	Response	Frequency	Percentage
Are you aware of smart wearables technology?	Yes	74	72.5
	No	26	25.5
	Maybe	2	2.0
	Total	**102**	**100.0**
Are you aware that smart wearable devices work with internet connectivity?	Yes	47	46.1
	No	38	37.3
	Maybe	17	16.7
	Total	**102**	**100.0**

4.4 Benefits of smart wearable devices for construction health and safety

Table 4 present the most five (5) benefits based on MIS and SD computation which are 'Increase productivity, health and wellness of human, connectivity and efficiency', 'Aids effective performance of employees and provide necessary help against potential danger within the workplace setting', 'Enhance effective documentations', 'Aids technician's support during fieldwork with the recorded video being transfer to central location' and 'Monitoring surrounding environment and gathered the necessary information within the surrounding, process it and output them for better understanding of the users.

Table 4: Benefits of smart wearable devices on construction health and safety

Benefits of smart wearable devices	Mean	Std. D	Rank
Increase productivity, health and wellness of human, connectivity and efficiency	3.79	1.075	1
Aids effective performance of employees and provide necessary help against potential danger within the workplace setting	3.77	1.033	2
Enhance effective documentations	3.73	1.026	3
Aids technician's support during fieldwork with the recorded video being transfer to central location	3.72	1.031	4
Monitoring surrounding environment and gathered the necessary information within the surrounding, process it and output them for better understanding of the users	3.72	0.999	5
Improvement in working condition and safety performance	3.71	0.897	6
Digitalization	3.68	0.836	7
Save time	3.68	1.026	8
Tracking physiological signs such as body temperature, blood pressure, blood oxygen saturation and heart rate	3.68	1.073	9
Assisting work scheduling, reduce cost and improve quality of work throughout the project life-cycle	3.66	1.029	10
Accurate collection, storing and transfer of data	3.66	1.058	11
Aids the prevention and reduction of workers expose to potential hazards	3.62	1.108	12
Accurate location tracking and proximity detection	3.59	1.189	13

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4.5 Difference in stakeholders' position and benefits of smart wearable devices on construction health and safety

The use of Kruskal-Walli's test was to determine if there was a significant difference in the stakeholders' views in respect to their position on site and the benefits of smart wearable devices on construction health and safety. As presented in Table 5, four (4) variables out of the thirteen (13) listed variables had asymptotic significance of 0.05 or less. This implies that position on site of construction stakeholders do not significantly influence their perception on the benefits of smart wearable devices on construction health and safety.

Table 5: Difference in stakeholders' position andbenefits of smart wearable devices on construction health and safety

	Respondent position on site					Kruskal Wallis	
Benefits of smart wearable devices	CLT	CNT	SW	HSO	OTH	Chi square	Asymp. Sig.
Tracking physiological signs such as body temperature, blood pressure, blood oxygen saturation and heart rate	3.86	4.13	3.28	3.79	3.50	11.775	**0.019**
Accurate collection, storing and transfer of data	3.91	4.00	3.56	3.21	2.75	11.514	**0.021**
Monitoring surrounding environment and gathered the necessary information within the surrounding, process it and output them for better understanding of the users	3.64	4.00	3.64	3.64	3.50	2.330	0.675
Aids effective performance of employees and provide necessary help against potential danger within the workplace setting	3.50	4.13	3.87	3.50	3.25	7.108	0.130
Aids technician's support during fieldwork with the recorded video being transfer to central location	3.86	4.04	3.64	3.36	3.25	5.168	0.271
Aids the prevention and reduction of workers expose to potential hazards	3.91	3.65	3.44	3.71	3.25	4.562	0.335
Improvement in working condition and safety performance	3.64	3.78	3.64	4.00	3.25	3.951	0.413
Assisting work scheduling, reduce cost and improve quality of work throughout the project life-cycle	3.55	3.91	3.49	3.71	4.25	4.111	0.391
Increase productivity, health and wellness of human, connectivity and efficiency	3.64	3.96	3.77	3.86	3.75	1.028	0.906
Accurate location tracking and proximity detection	3.68	3.74	3.62	3.36	2.75	4.758	0.313
Save time	3.50	4.22	3.49	3.71	3.25	11.477	**0.022**
Digitalization	3.73	4.13	3.54	3.36	3.25	10.569	**0.032**
Enhance effective documentations	3.95	4.04	3.51	3.50	3.50	6.839	0.145

Note: CLT Client; CNT – Contractor; SW – Site Worker; HSO – Health Safety Officer; OTH – Others

4.6 Difference in years of experience and benefits of smart wearable devices on construction health and safety

The use of Kruskal Wallis test was to examine if there was a significant difference in the stakeholders' perceptions based on their professional experience on thebenefits of smart

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wearable devices on construction health and safety. As shown in Table 6, the listed variables were not significant as their p-value were above 0.05. This implies that the professional experience of construction stakeholders does not significantly influence their benefits of smart wearables device on construction health and safety.

Table 6: Difference in years of experience benefits of smart wearable devices on construction health and safety

	Respondent years of experience					Kruskal Wallis	
Benefits of smart wearable devices	Less than 5yrs	6-10 yrs	11-15 yrs	16-20 yrs	Above 21yrs	Chi square	Asymp. Sig.
Tracking physiological signs such as body temperature, blood pressure, blood oxygen saturation and heart rate	3.45	3.73	3.82	3.73	4.00	1.159	0.885
Accurate collection, storing and transfer of data	3.39	3.80	3.64	3.91	4.50	4.751	0.314
Monitoring surrounding environment and gathered the necessary information within the surrounding, process it and output them for better understanding of the users	3.42	3.93	3.75	3.82	4.00	4.971	0.290
Aids effective performance of employees and provide necessary help against potential danger within the workplace setting	3.87	3.73	3.54	4.09	4.50	5.068	0.280
Aids technician's support during fieldwork with the recorded video being transfer to central location	3.67	3.67	3.75	3.82	4.50	1.795	0.773
Aids the prevention and reduction of workers expose to potential hazards	3.61	3.40	3.86	3.55	4.00	3.125	0.537
Improvement in working condition and safety performance	3.97	3.37	3.68	4.00	3.50	10.545	**0.032**
Assisting work scheduling, reduce cost and improve quality of work throughout the project life-cycle	3.65	3.53	3.75	3.64	4.50	3.626	0.459
Increase productivity, health and wellness of human, connectivity and efficiency	3.87	3.77	3.82	3.64	3.50	1.834	0.766

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Accurate location tracking and proximity detection	3.39	3.50	3.82	3.73	4.00	1.637	0.802
Save time	3.48	3.80	3.68	3.73	4.50	2.875	0.579
Digitalization	3.35	3.80	3.89	3.64	4.00	3.923	0.417
Enhance effective documentations	3.48	3.93	3.93	3.36	3.50	2.580	0.630

V. DISCUSSION OF FINDINGS

After distributing a questionnaire on the fourteen (14) claimed benefits culled from the literature, the benefits of the device for construction health and safety, as ranked by stakeholder opinions and submitted to analysis, are as follows.; Increase productivity, health and wellness of human, connectivity and efficiency'as supported in the findings of PricewaterhouseCoopers (2014) that the device is potent in improving productivity and efficiency coupled with wellbeing of an individual. Also, it aids effective performance of employees and provide necessary help against potential danger within the workplace setting which agrees with the work of Khakurel, Melkas, and Porras, (2018) and Giddens, Leidner& Gonzalez, (2017) that the performance and productivity of an employee in an organization depend on his health which the device work to improve. Furthermore, enhancing effective documentations agrees with Vaduganathan& Bhatt (2015) that wearable devices aid documentation and preservation of information quality and aiding technician's support during fieldwork with the recorded video being transfer to central location as opined by AL-Sahar et al. (2021) research work. In addition,the device monitors surrounding environment and gathered the necessary information within the surrounding, process it and output them for better understanding of the users which justifies Fernández-Caramés& Fraga-Lamas (2018) andAwolusiet al., (2019)that the devices have the ability to detect danger, process it and send the information as warning signal to workers on site research.

Additionally, the Kruskal-Wallis test was used to determine whether the stakeholders' perceptions of their roles on the job site and the benefits of smart wearables for construction health and safety were statistically different. It was shown that there is no connection between construction stakeholders' positions and how they perceive the benefits of smart wearables for workplace health and safety. Meanwhile, the stakeholders must be aware that these tools are effective at tracking body temperature, heart rate, respiration rate, and blood oxygen saturation as pointed out by Karjalainen &Viitasalo (1986) research work and also reduce the amount of time needed to check on someone's health (Aroganam, Manivannan& Harrison, 2019).

Finally, based on their professional experiences, stakeholders' assessments of the benefits of smart wearables for construction health and safety were compared using the Kruskal-Wallis test to see if there were any discrepancies. The benefits of smart wearables for construction health and safety and year of professional experience were shown to not significantly differ from one another. Meanwhile, the perceptions of the stakeholders must anticipate improvements to working conditions and safety performance (Azeez &Gambatese, 2018) of the device as benefit that impacted construction safety positive.

VI. CONCLUSION AND RECOMMENDATION

The study assessed the benefits of smart wearable devices for construction health and safety, the research revealed that the stakeholders are knowledgeable about the existence of the devices and its connectivity with internetThe benefits of this device will also increase productivity and efficiency of site workers, safeguard their health and wellness coupled with effective performance of employees and provide necessary help against potential danger within the workplace setting. Adopting the device will enhance effective documentations and aids technician's support during fieldwork with the recorded video being transfer to central location coupled with monitoring of surrounding environment and gathered the necessary information within the surrounding, process it and output them for better understanding of the users or site workers.

These benefits encapsulated what was required to ensure the highest level of worker performance and safety on the building site. This study confirmed that the benefits associated with these gadgets will increase the health and safety of the construction industry. As a result, the government and stakeholders in the construction sector need to focus more on raising consciousness about the benefits and functionality of these devices in the sector.

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