

Key Drivers of Wearable Technology Usage for Worker Safety on Construction Sites in Nigeria

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Abstract

Despite significant advancements in wearable technology, the construction industry faces high rates of accidents, injuries, and fatalities. Hence, this study aims to evaluate the key drivers of wearable technology in Nigeria's construction sites to foster the health and safety of workers and other stakeholders in building projects. A post-positivist philosophical approach guided a quantitative research methodology employing a questionnaire survey for this study. The population comprises professionals with health and safety certifications who interact with safety protocols and wearable technology on construction sites within Lagos state. Using snowball sampling, 360 questionnaires were distributed online and physically; 164 copies were retrieved, screened, and analysed using descriptive analysis. The ranking of drivers reveals that enhanced safety outcomes, regulatory compliance, and potential cost savings are the primary motivations for adopting wearable technology. The standard deviation results showed that the responses from the survey were consistent and uniform since all their values were less than one (1). Based on the findings of this research, it is recommended that government bodies introduce policies that incentivise the adoption of wearable technology through subsidies or tax benefits. Regulatory frameworks should also be established to standardise the use of these technologies across the industry. The outcome of this study points to the need for further exploration into the long-term sustainability and cost-effectiveness of wearable technology in the construction industry. Additionally, it opens the door for research into how these technologies could be integrated into safety protocols in other regions or sectors within Nigeria.

Keywords: Wearable Technologies, Health and Safety, Construction Sites, Drivers, Nigeria

1. Introduction

The construction industry is a key sector of the economy as it is engaged in building structures that form the framework of societies and economies. Though it is a crucial industry, it is one of the riskiest industries in terms of accidents, injuries, and fatalities (Griffiths et al., 2017). Making improvements to safety in this industry is paramount, and as we have seen with the developments in wearable technologies, they could be the fix we need. It gives real-time monitoring information, reducing many of the risks typical of construction sites (Chen *et al.*, 2023). Wearable technology refers to a group of gadgets that are worn on the body or integrated into garments. These devices are smart helmets, wearable sensors, bright vests, and augmented reality. Glasses or goggles aim to improve the worker's safety by tracking the worker's environment and health status. For instance, smart helmets can identify the driver's fatigue and attentiveness levels; wearable biosensors can track physiological conditions and toxic substances in the surroundings; and smart vests can help locate a worker to prevent accidents such as collisions and falls (Chen et al., 2023). Implementing these technologies in the construction sector is expected to bring several benefits, such as fewer accidents, increased production, and improved workplace safety (Okoye *et al.*, 2017). However, there are reasons wearable technology has

not been fully embraced in the construction industry. The existing literature highlighted several sources of the issue, such as high costs, non-standardisation, change management resistance, and training insufficiency, as key challenges (Umeokafor & Teizer, 2023). Moreover, identifying the factors influencing people to incorporate wearable tech devices is crucial for driving their acceptance (Okpala et al., 2022). Some factors, including safer practices, compliance with the law, the possibility of reduced costs, and higher productivity, are always considered when construction firms decide which measures to adopt (Davis, 1989). Understanding these drivers will help stakeholders formulate specific measures that suit the popularisation of wearable technology.

Despite significant advancements in wearable technology, the construction industry faces high rates of accidents, injuries, and fatalities. This remains the case when wearable devices that can monitor and analyse protective data in real-time are available to boost the protection of workers (Griffiths et al., 2017). The author also found a high frequency of different types of accidents, indicating that the opportunity for wearable technology and smart garments to enhance safety performance on construction sites remains unexplored. There is a significant research gap in identifying how well these technologies are being adopted and for what purposes in practice (Chen *et al.*,

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2023). This work employs a survey research method and collects primary data from a large pool of participants, including construction employees, site supervisors, and safety personnel.

This study aims to evaluate the key drivers of wearable technology in Nigeria's construction sites to foster the health and safety of workers and other stakeholders in building projects. The outcome of this research will be a valuable addition to the literature on wearable technology in construction, possessing practical implications for various stakeholders in the construction sector. Thus, this study seeks to address the barriers by promoting the use of wearable technology and leveraging key drivers to enhance its implementation in construction safety, thereby improving the safety of construction workers and reducing the high incidence of accidents and injuries in the construction industry.

2. Wearable Technology in Construction

Wearable technology encompasses various devices worn on the body to monitor, collect, and analyse data in real-time. In the construction industry, these devices include smart helmets, wearable sensors, smart vests, and augmented reality glasses (Tetteh et al., 2024). These technologies aim to enhance safety by providing real-time information about the worker's physical condition and environmental hazards, thereby enabling prompt intervention and the prevention of accidents (Nnaji et al., 2020). Smart helmets, for instance, are equipped with sensors that can detect fatigue, alertness levels, and even environmental conditions such as temperature and humidity (Khosravi et al., 2021). These helmets can alert workers and supervisors if there are signs of heat stress, dehydration, or other health issues, allowing for timely interventions to prevent accidents and enhance worker safety.

Additionally, smart helmets can be integrated with augmented reality features, providing workers with visual overlays of construction plans and real-time data about their surroundings, which can improve accuracy and reduce errors (Oke & Arowoia, 2022). Smart helmets represent a significant advancement in personal protective equipment for construction workers. These innovative helmets are embedded with various sensors to monitor crucial physiological parameters, including heart rate, body temperature, and fatigue (Campero-Jurado et al., 2020). By continuously tracking these vital signs, smart helmets can detect anomalies that may indicate health issues or the onset of fatigue, thereby preventing accidents before they occur. These advanced features make smart helmets an invaluable tool for enhancing worker safety on construction sites. By providing continuous health monitoring, precise location tracking, seamless communication, and timely alerts, smart helmets protect workers from immediate dangers and contribute

to the overall safety culture of the construction industry (Ibrahim et al., 2023).

Wearable sensors are another critical component of wearable technology in construction (Ibrahim et al., 2025). These sensors can be embedded in clothing or worn as standalone devices such as wristbands or armbands (Okpala et al., 2021). They monitor various physiological parameters, including heart rate, body temperature, and movement patterns. By analysing this data, the sensors can detect signs of physical strain, overexertion, or dangerous fatigue levels, prompting immediate action to prevent injuries. Wearable sensors have emerged as invaluable tools within construction site environments, strategically deployed to monitor and enhance various aspects of safety and productivity (Ahn et al., 2019). These devices can be affixed to workers' clothing or equipment, providing continuous real-time data on critical parameters such as movement, posture, and exposure to hazardous substances like chemicals or particulate matter. For instance, wearable sensors are adept at detecting sudden falls or accidents, promptly alerting supervisors and emergency response teams to minimise response times and mitigate injuries (Umeokafor & Teizer, 2023). This capability is crucial in high-risk construction environments where immediate intervention can differentiate between minor incidents and serious harm. Moreover, the integration of wearable sensors on construction sites goes beyond safety. They also play a pivotal role in optimising workflow efficiencies by monitoring workers' activity levels and fatigue, helping to schedule breaks and tasks more effectively. This proactive approach enhances productivity and reduces the likelihood of accidents caused by worker fatigue or overexertion (Ibrahim et al., 2023). In addition to enhancing safety and productivity, wearable sensors improve overall site management by providing comprehensive data insights (Turner et al., 2020). This data can inform decision-making processes related to resource allocation, task prioritisation, and equipment maintenance, fostering a more streamlined and efficient construction operation (Jones et al., 2018). Overall, wearable sensors represent a transformative technology in the construction industry, offering multifaceted benefits that range from enhancing safety protocols and productivity to optimising management strategies. As these devices evolve, their integration into construction practices promises to elevate further safety standards, efficiency, and overall project outcomes.

Smart vests combine multiple wearable technologies, including sensors and GPS, to provide comprehensive safety monitoring. These vests can track workers' locations, detect hazardous conditions, and communicate alerts to the workers and the site management team (Edirisinghe, 2019). Integrating various sensors allows smart vests to monitor various physiological and environmental parameters. Moreover, the data collected by smart vests can be used

to analyse patterns and identify recurring safety issues, allowing for proactive measures to prevent future incidents (Edirisinghe, 2019). Smart vests also contribute to improving overall site efficiency. By tracking the location and movement of workers, site managers can optimise workflows, reduce idle times, and ensure that personnel are deployed effectively. This capability enhances productivity and helps coordinate emergency responses more efficiently. In addition, smart vests can support compliance with safety regulations by providing detailed records of safety conditions and responses on-site (Jones et al., 2018; Cai et al., 2023).

In conclusion, smart vests represent a significant advancement in wearable technology for construction safety. By combining real-time monitoring, alerting systems, and data analytics, these vests offer a multifaceted approach to managing safety risks. As the construction industry evolves, adopting smart vests and other wearable technologies will likely play a crucial role in creating safer and more productive work environments. These wearable technologies enhance safety by providing real-time information about the worker's physical condition and environmental hazards. This immediate feedback allows for prompt intervention and the prevention of accidents, ultimately creating a safer and more efficient work environment. By leveraging the capabilities of wearable technology, the construction industry can significantly reduce the incidence of accidents, improve worker health and safety, and increase overall productivity.

3. Research Methodology

This study adopted a post-positivist philosophical approach to establish the key drivers of wearable technology usage on construction sites in Nigeria. This philosophical viewpoint guided a quantitative research methodology employing a questionnaire survey. Creswell (2014) states that the quantitative research approach collects numerical data that may be categorised, ranked, or assessed using units of measurement. Using data from the reviewed literature, a closed-ended questionnaire was created for this study to collect data from the target population. The target population for this study included construction workers, site managers, safety officers, and other stakeholders involved in construction projects in Lagos State. These individuals were selected based on their interaction with safety protocols, health and safety certification, and wearable technology on construction sites. The study's design required a snowballing sampling technique—a method of gathering data in which research participants help recruit new study participants. Research using hardly identifiable respondents has employed this method (Mould-Millman et al., 2017; Akinradewo et al., 2022; Ebiloma et al., 2024). Two building professionals from academia and industry were chosen to achieve this, and

additional professionals and stakeholders who met the study's requirements and were eligible to participate were also found.

There were two distinct sections of the questionnaire. Section A collected background information from the respondents, while Section B concentrated on the key drivers of wearable technologies. Participants used the survey's 5-point Likert scale to indicate their level of agreement or disagreement with the factors. A 5-point Likert-type scale increased answer quality and rate while reducing respondents' frustration (Joshi et al., 2015). Tables and charts were used to derive statistical conclusions based on their responses. Microsoft Excel and the Statistical Package for Social Science (SPSS) software were used to analyse the data. The mean item scores, percentiles, and frequencies were computed from the collected data. Percentiles and frequencies were used to examine the respondents' demographic data, and the mean item score was used to sort the variables according to the respondents' answers. 164 copies of the 360 survey questionnaires that were distributed were recovered. Every recovered questionnaire was examined and determined to be appropriate for analysis. The filled questionnaires represented a response rate of 45.5%; this is considered robust for a study of this nature, significantly exceeding the 30% threshold commonly accepted as a satisfactory response rate in construction-related studies (Ryal-Net & Kaduma, 2015). This high response rate strengthens the validity of the study's findings. It contributes to the depth of insights regarding the use of wearable technologies on construction sites in Lagos State, Nigeria. Cronbach's alpha was used to assess the study instrument's reliability; the results showed an alpha value of 0.926, confirming the validity of the data obtained from the questionnaire survey.

4. Findings and Discussion

4.1. Socioeconomic Background of Respondents

The analysis of the socioeconomic background of the respondents, who are professionals in the Nigerian construction industry, particularly in Lagos State, aims to verify the suitability of the respondents to provide adequate information to achieve the study's objective. To verify the respondents' suitability and reliability of the information provided, the following background information was requested: profession, years of experience, educational qualification, and professional registration status.

As presented in Table 1 in terms of profession, builders make up the most significant proportion (51.2%) of respondents, followed by Quantity Surveyors (20.7%), Safety Officers (9.8%), Electrical Engineers (7.9%), Civil Engineers (6.7%), and Mechanical Engineers (3.7%). This distribution suggests that the study has adequately represented the various professions within

Table 1: Socioeconomic Background of the Respondents

Characteristics	Frequency (n=164)	Percentage
Profession		
Builder	84	51.2%
Civil Engineer	11	6.7%
Electrical Engineer	13	7.9%
Mechanical Engineer	6	3.7%
Quantity Surveyor	34	20.7%
Safety Officer	16	9.8%
Years of Experience		
1 - 5 years	102	62.2%
6 - 10 years	55	33.5%
11 - 15 years	5	3.0%
16 – 20 years	2	1.2%
Educational Qualification		
B.SC	115	70.1%
HND	12	7.3%
M.SC	33	20.1%
PHD	3	1.8%
OND	1	0.6%
Professional Registration Status		
Corporate	6	3.7%
Graduate	143	87.2%
Licentiate	5	3.0%
Technician	10	6.1%

(Source: Author's Survey)

the construction industry. The analysis of professional experience reveals that most respondents have 1-5 years of experience (62.2%), while 33.5% have 6-10 years, 3% have 11-15 years, and 1.2% have 16-20 years. This indicates a relatively young and experienced workforce. Regarding educational qualification, most respondents hold a Bachelor's degree (70.1%), followed by a Master's degree (20.1%), a Higher National Diploma (HND) (7.3%), Doctor of Philosophy (PhD) (1.8%), and an Ordinary National Diploma (OND) (0.6%).

This high level of educational attainment suggests that the respondents are knowledgeable and competent in their respective fields. The professional registration status of the respondents indicates that the majority (87.2%) are Graduate members of their respective professional bodies, followed by Corporate members (3.7%), Licentiate members (3%), and Technician members (6.1%). This suggests that the respondents are professionally qualified and registered. The socioeconomic background analysis indicates that the respondents are suitable and reliable sources of information for achieving the study's objectives.

4.2. Key Drivers of Wearable Technology Usage on Construction Sites

The key drivers behind the adoption of wearable technology in the construction industry are presented in Table 2. This table provides an overview of the mean scores and standard deviations for 25 potential drivers.

Improved worker safety and risk reduction emerged as the top driver, with a mean score of 4.30, indicating that respondents strongly associate wearable technology with enhanced safety and reduced risk. Enhanced productivity and efficiency followed closely with a mean score of 4.01. Real-time data analysis and insights, compliance with regulatory requirements, and competitive advantage and market differentiation also ranked highly, with mean scores ranging from 3.99 to 3.97. These scores suggest that respondents value wearable technology for its potential to improve operational performance, decision-making, and competitiveness. Other significant drivers include cost savings and return on investment (3.97), improved worker health and well-being (3.96), enhanced collaboration and communication (3.96), and increased transparency and accountability (3.95). These findings highlight the importance of wearable technology in promoting a safe, healthy, and productive work environment. The ranking of drivers reveals that safety, productivity, and efficiency are the primary motivations for adopting wearable technology. The lowest-ranked drivers include alignment with organisational goals and objectives (3.77), access to new technologies and innovations (3.82), and improved data-driven decision-making (3.80). The standard deviation results showed that the responses from the survey were consistent and uniform since all their values were less than one (1).

Table 2: Descriptive Statistics for Key Drivers of Wearable Technology Usage

Drivers	Mean	Std. Deviation	Rank
Improved worker safety and risk reduction	4.30	.929	1
Enhanced productivity and efficiency	4.01	.739	2
Real-time data analysis and insights	3.99	.779	3
Compliance with regulatory requirements	3.99	.783	4
Competitive advantage and market differentiation	3.97	.713	5
Cost savings and return on investment	3.97	.787	6
Improved worker health and well-being	3.96	.759	7
Enhanced collaboration and communication	3.96	.712	8
Increased transparency and accountability	3.95	.785	9
Better decision-making and planning	3.94	.781	10
Improved incident response and emergency management	3.94	.757	11
Enhanced supply chain management	3.93	.788	12
Improved asset tracking and management	3.92	.700	13
Environmental sustainability and reduced waste	3.92	.759	14
Improved worker training and development	3.91	.832	15
Improved customer satisfaction and experience	3.91	.813	16
Enhanced project management and control	3.90	.769	17
Improved quality control and assurance	3.90	.884	18
Reduced workers' compensation claims	3.90	.788	19
Improved business continuity and resilience	3.87	.837	20
Enhanced reputation and brand image	3.84	.791	21
Improved stakeholder engagement and trust	3.84	.821	22
Access to new technologies and innovations	3.82	.793	23
Improved data-driven decision-making	3.80	.745	24
Alignment with organisational goals and objectives	3.77	.778	25

(Source: Author's Survey)

5. Discussion of Findings

This study identifies enhanced safety outcomes, regulatory compliance, and potential cost savings as primary drivers for wearable technology adoption, aligning with existing literature (Chen et al., 2023; Tetteh et al., 2024). Enhanced safety outcomes emerged as the primary driver, consistent with previous findings (Chen et al., 2023; Tetteh et al., 2024). Wearable devices provide real-time monitoring and alerts, reducing the likelihood of accidents and improving response times. Regulatory compliance, encouraged by bodies like the Occupational Safety and Health Administration (OSHA), is another significant driver (Mollo, 2024). Firms recognise the importance of adhering to safety regulations. Potential cost savings through reduced accidents, lower insurance premiums, and increased productivity drive adoption (Chen et al., 2023). The study's findings corroborate existing literature, highlighting the importance of safety, compliance, and cost savings.

The construction industry's adoption of wearable technology is driven by a desire to improve worker safety, productivity, and efficiency. Wearable technology supports regulatory compliance and cost

savings and enhances collaboration, transparency, and accountability. The findings suggest that organisations value wearable technology for its potential to transform the construction industry. By understanding these key drivers, stakeholders can develop targeted strategies to promote the adoption of wearable technology. Adopting wearable technology can benefit the construction industry, including improved worker safety, increased productivity, and enhanced competitiveness. As the industry continues to evolve, wearable technology will likely play a critical role in shaping its future.

6. Conclusion and Further Research

The study's results conclusively demonstrate that wearable technology has the potential to transform the construction industry by enhancing productivity, safety, and efficiency. The findings highlight the significance of wearable technology in improving construction processes, reducing errors, and enhancing worker well-being. However, successful implementation requires careful consideration of cost management, standardisation, change management, and comprehensive training. The study identified key drivers of wearable technology adoption, including improved productivity, enhanced safety, and increased

efficiency. Based on the findings of this research, it is recommended that government bodies introduce policies that incentivise the adoption of wearable technology through subsidies or tax benefits. Regulatory frameworks should also be established to standardise the use of these technologies across the industry. The outcome of this study points to the need for further exploration into the long-term sustainability and cost-effectiveness of wearable technology in the construction industry.

Additionally, it opens the door for research into how these technologies could be integrated into safety protocols in other regions or sectors within Nigeria. Future studies could evaluate the return on investment (ROI) over an extended period and examine how wearable technology impacts project costs, profitability, and operational efficiency in the long run. This study focused on wearable technology as an independent safety tool. However, future research could examine how these devices can be seamlessly

integrated into broader occupational health and safety systems already in use on construction sites. Understanding how wearable technology interacts with current safety practices will provide deeper insights into how best to implement these technologies for maximum effectiveness.

Additionally, future studies could explore the regional and sectoral differences in the adoption of wearable technology. This research focused on Lagos State, Nigeria, but technology adoption may vary significantly across different regions and sectors within the construction industry. Comparative studies across other states or countries and exploring adoption in specialised construction sectors (e.g., infrastructure projects, residential buildings) would offer a more comprehensive understanding of the factors influencing the uptake of wearable technology.

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