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IMPACT OF EMERGING TECHNOLOGY ADOPTION ON SAFETY PERFROMANCE OF MANUFACTURING COMPANIES IN NIGERIA

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Abstract

This paper examined the impact of emerging technologies adoption on workplace safety in manufacturing industries in Nigeria. Six emerging technologies were explored. workplace safety was evaluated using safety outcomes, safety participations and safety compliance. Cross-sectional research design was adopted. Stratified random sampling technique was used. Sample sizes was 345 determined using Taro Yamane's sample size determination formula. Data were collected using structured questionnaire based on 5-point Likert scale. SPSS version 24 was used for data analyses; percentages and weighted mean scores (WMS) were computed using descriptive statistics and regression analysis. Results of descriptive statistics revealed emerging technology adoption was low in Nigeria manufacturing firms (WMS=2.94<3.00). There is moderate level of safety outcome, compliance and participation in manufacturing firms in Nigeria (WMS=3.00, 3.21, and 3.26>3.00). Results of regression analysis showed that emerging technology adoption has positive and significant impact on safety outcome (B=1.198, p-value<0.0001) while its impact on safety compliance (B=0.064, p-value<0.073)) and safety participation (B=0.068, p-value<0.651) were positive but insignificant. Conclusively, emerging technology adoption improved workplace safety moderately in manufacturing firms in Nigeria. Therefore, stakeholders in manufacturing sector in developing countries like Nigeria should provide infrastructure and regulatory framework required for adequate adoption of emerging technology for workplace safety in the sector.

Keywords:

Emerging Technology, Adoption, Safety Performance, Manufacturing Companies, Nigeria.

1.1 INTRODUCTION

The rapid evolution of technology is fundamentally transforming the landscape of workplace safety, ushering in a new era of innovative solutions that have the potential to enhance the well-being of workers significantly (Flor-Unda et al., 2023). This evolution is evident in various aspects, from advanced monitoring systems to wearable devices, offering novel approaches to safeguarding employees and mitigating risks of accidents and injuries (Shalender et al, 2023). The transformation is driven by advancements in various fields, including artificial intelligence (AI), the Internet of Things (IoT), wearable technology, robotics, and data analytics, among others. One of the key aspects of this transformation is the increased focus on proactive safety measures rather than reactive responses to incidents. Traditionally, workplace safety

performance has often been reactive, with measures taken after accidents or injuries occur. However, with the advent of new technologies, there is a shift towards proactive safety measures that aim to prevent accidents from happening in the first place (Shalender et al, 2023).

The integration of automation, robotics, and artificial intelligence (AI) into workplaces is rapidly transforming how work is performed, bringing both opportunities and challenges in workplace safety. As these emerging technologies are increasingly adopted, they introduce novel occupational hazards that require new safety protocols. For instance, robots, while capable of performing repetitive tasks with high precision, can also pose physical dangers if they malfunction or if human workers come too close without proper safeguards. A notable incident that exemplifies the importance of this transformation occurred on June 30, 2015, at a Volkswagen assembly line in Baunatal, Germany (Muralidhar et al., 2023). During the installation of an industrial robot by a third-party contractor, a tragic event unfolded, resulting in the death of a worker. The robot gripped and pressed the worker against a metal plate, causing fatal chest injuries. Despite immediate medical intervention, the worker passed away (Muralidhar et al., 2023). This incident, along with similar occurrences, has raised significant concerns regarding the safety of human-robot interactions in industrial environments. It underscores the urgent need for improved safety measures and protocols to safeguard workers from such hazards.

Several industries illustrate the dual impact of emerging technologies on workplace safety. In the manufacturing sector, the adoption of robotics has led to increased productivity but also necessitated stringent safety protocols to manage human-machine interaction (Yang et al., 2017). AI in quality control helps identify defects early in the production process, reducing the risk of defective products causing harm. In healthcare, automated systems in laboratories have improved the accuracy and speed of testing, but also require rigorous safety standards to protect against biohazards and mechanical failures. AI-driven patient monitoring systems provide continuous observation and immediate alerts for critical conditions, enhancing patient safety. In the construction sector, emerging technologies such as drones, wearable devices, and Building Information Modeling (BIM) are revolutionizing workplace safety (Musarat et al., 2022). Drones play a crucial role in enhancing safety and compliance on construction sites by providing aerial views for hazard identification and safety protocol enforcement. These unmanned aerial vehicles (UAVs) enable efficient monitoring, timely error detection, and quick corrective actions, ultimately reducing accidents and improving overall safety performance. The use of drones in construction projects offers benefits such as increased efficiency, accuracy in data collection, and improved project management through real-time monitoring. Wearable devices, such as smart helmets and vests, monitor workers' vital signs and environmental conditions, alerting them to potential dangers like heat stress or toxic gas exposure (Patel et al., 2022). BIM enhances safety by creating detailed 3D models of construction projects, allowing for better planning and hazard identification (Waqdan et al., 2023).

Recent advancements in environmental monitoring systems integrate Internet of Things (IoT) technology and sophisticated sensors to track air quality, water pollution, and waste management, enhancing global sustainability efforts (Laha et al., 2022). Artificial intelligence (AI) and IoT-driven technologies are increasingly used for detecting hazardous substances in the environment, with machine learning methods revolutionizing environmental science (Popescu et al., 2024). AI applications in agriculture, forestry, and marine resource extraction are rapidly growing, though they present potential systemic risks such as algorithmic bias and unequal access to benefits (Galaz et al., 2021). Various AI approaches, including artificial

neural networks and fuzzy logic, have been developed for environmental pollution control, offering predictive models, optimization algorithms, and intelligent control systems for wastewater treatment, air quality monitoring, and solid waste management (Ye et al., 2020). These technologies provide valuable tools for addressing environmental challenges and improving pollution control strategies. These innovative tools offer real-time monitoring, predictive analytics, immersive training experiences, and increased efficiency, which collectively enhance safety measures and reduce the risk of accidents. In developed countries, the adoption of these technologies is more prevalent due to higher financial resources, stronger regulatory support, and better infrastructure (Li & Poon, 2013). Large companies in these regions are often at the forefront of implementing these technologies, benefitting from enhanced safety protocols and reduced incidents (Li & Poon, 2013).

Conversely, developing countries face considerable challenges in adopting emerging technologies for workplace safety, especially within small scale manufacturing firms (Yap et al., 2022). These companies face several barriers when it comes to adopting advanced safety technologies (Masi & Cagno, 2015). The high costs associated with these technologies are a primary barrier, as they usually operate with limited budgets and cannot afford significant upfront investments (Masi & Cagno, 2015). Additionally, there is often a lack of awareness about the benefits and availability of these technologies, coupled with infrastructure challenges such as unreliable internet connectivity (Welter & Schröder, 2016). The weaker regulatory frameworks and less governmental support for technological innovation further hinder the adoption rates in these regions. The sector-specific implementation also shows a disparity between large enterprises and SMEs. Large companies have greater financial and human resources, allowing them to invest in and maintain advanced safety technologies (Huang et al., 2011). However, companies in developing countries may also face challenges such as limited working capital and investment, difficulties in marketing and distribution, limited access to information about market opportunities and lack of expertise in implementing advanced technologies (Unnikrishnan et al., 2015). Smaller firms are also constrained by their limited resources and often focus on more cost-effective, traditional safety measures, which might not be as effective as the latest technological solutions (Huang et al., 2011).

The integration of advanced technologies in workplace safety protocols is multifaceted. Continuous data analytics facilitate real-time monitoring of workers' health, enabling prompt responses to potential hazards. Ergonomic improvements in workplace design, powered by AI and Machine Learning (ML), contribute to creating comfortable and safe environments, reducing physical strain and the risk of musculoskeletal disorders (Donisi et al., 2020). The influence of these technologies extends beyond physical safety to the organization of work itself. The implementation of AI and automation can lead to significant changes in job roles and work processes, potentially introducing new stressors and ergonomic challenges. Workers may need to adapt to new ways of interacting with machines, which can include both physical and cognitive demands. AI and automation have the potential to significantly enhance workplace safety by reducing human error and performing dangerous tasks that would otherwise put human workers at risk. Automated systems can continuously monitor workplace conditions, identify potential hazards, and even predict equipment failures before they occur, thereby preventing accidents. However, the reliability of these systems is crucial; any malfunction or software error can lead to catastrophic consequences (Donisi et al., 2020).

The influence of these technologies on workplace safety performance is significant. Enhanced safety measures have become possible with real-time monitoring through sensors and AI,

allowing for the prompt identification and addressing of hazards (Shah & Mishra, 2024). Predictive maintenance powered by AI can foresee equipment failures, reduce downtime and prevent accidents caused by malfunctioning machinery (Shah & Mishra, 2024). However, the complexity of systems integrating these technologies adds new layers of risk. Specialized knowledge and training are required to manage and operate these advanced systems safely. Additionally, as workplaces become more reliant on interconnected systems, the risk of cyber-attacks increases, potentially leading to safety breaches. Another significant impact of emerging technologies on workplace safety performance is the improvement in ergonomics and worker health. Wearable devices and exoskeletons are revolutionizing how workers interact with their environment, reducing strain and the risk of musculoskeletal disorders. Exo-skeletons can assist workers in lifting heavy objects, reducing the likelihood of injuries (De merick et al., 2020). Virtual reality (VR) and augmented reality (AR) technologies are being used for training purposes, allowing workers to simulate hazardous scenarios without real-world risks. This enhances their preparedness and decision-making in high-risk situations, ultimately improving overall safety outcomes.

The integration of big data analytics and machine learning in safety management systems enables organizations to proactively identify and mitigate potential safety risks (Ajayi et al., 2020; Hajar et al., 2023). By analyzing vast amounts of data collected from sensors, equipment, and workers, patterns and trends can be identified, leading to the implementation of targeted safety measures (Ajayi et al., 2020; Goel et al., 2020). Machine learning algorithms can predict future hazards and prevent accidents by analyzing near-miss incidents and other safety-related data (Hajar et al., 2023; Goel et al., 2020). This data-driven approach enhances the effectiveness of safety protocols, making workplaces safer and more efficient (Ajayi et al., 2020; Niu et al., 2024). However, challenges remain, including the need for a systematic framework to guide big data applications in safety, improving model interpretability, and integrating safety-related data with domain knowledge (Niu et al., 2024).

Human resources, often referred to as the workforce, are the backbone of any organization. The skills, knowledge, and efforts of employees drive productivity, innovation, and ultimately the success of the organization (Trost, 2020). As such, maintaining a healthy workforce is not just beneficial but essential for the organization's continued prosperity (Lowe, 2010). Technologies like intelligent devices for monitoring worker health and safety and AI-based solutions for identifying safety risks rely on employee feedback to enhance their effectiveness (Flor-Unda et al., 2023; Shah & Mishra, 2024). Moreover, the impact of new technologies, such as collaborative robots, on workers' psychological well-being is a key consideration, emphasizing the importance of employee involvement in the development and implementation process (Fraboni et al., 2023). Also, the Technology Impact Method (TIM) emphasizes the need for employees to possess digital, analytical, and communicative skills to adapt to technological advancements in the workplace (Hulsegge et al., 2022). This ongoing feedback loop between employees and technology developers ensures that safety tools evolve to address real workplace needs, ultimately improving their relevance and impact on safety protocols (Hulsegge et al., 2022). While technology can improve efficiency, its impact on work quality depends on how organizations implement it (Hulsegge et al., 2022).

The integration of emerging technologies like automation, robotics, and AI into workplace safety protocols offers significant benefits in terms of efficiency and safety. However, these advancements also introduce new occupational hazards and risk conditions that must be carefully managed. Successful integration requires a multifaceted approach that encompasses

robust safety measures, continuous monitoring and maintenance, ergonomic considerations, and updated regulatory frameworks. By proactively addressing these challenges, we can fully harness the potential of these technologies to create safer, more efficient workplaces. Ensuring workplace safety remains a critical concern for both individuals and organizations, as unsafe work environments can lead to severe consequences such as accidents, injuries, and fatalities. Research in this area has expanded over the years, providing valuable insights into the factors that influence workplace safety across different organizational levels. Despite this progress, challenges remain, including a lack of comprehensive theoretical frameworks and empirical integration in the literature on workplace safety.

The workforce plays a vital role in the use and influence of emerging technologies in workplace safety performance. Leveraging their feedback, knowledge, leadership, adaptability, and well-being is essential to ensure that safety technologies are effectively integrated and continuously improved. This collaborative approach not only enhances workplace safety but also fosters a culture of innovation and resilience. Thus, evaluating impact of emerging technology adoption on workplace safety performance necessitates a comprehensive and proactive approach. This holistic research approach focused on evaluating the impact of emerging technologies adoption on safety outcome which encompassed accident and incident occurrence as well as safety behaviour which encompassed safety compliance and safety participation in manufacturing firms operating in Nigeria. The study examined the level of adoption of emerging technologies for workplace safety across different industries across the selected countries, determine the level of workplace safety performance in the manufacturing industries across the selected countries and investigate the impact of emerging technologies adoption on workplace safety performance in the manufacturing industries in the selected countries

2.0 METHODOLOGY

2.1 Research Design

The study employed mixed-research design. This approach integrated both cross-sectional and analytical techniques. The cross-sectional aspect, the study used descriptive technique based on weighted mean scores to quantify the level of adoption of the emerging technologies for workplace safety protocols and to determine the level of workplace safety performance based on the response of the sampled respondents. Analytical design involved investigating the impact of adoption of emerging technology on the workplace safety performance in the study area

2.2 Study Area

The study is designed to gather data from manufacturing industries across multiple global locations, including Lagos and Port Harcourt in Nigeria, these two locations have been strategically chosen to offer a broad and comprehensive view of how emerging technologies are being utilized in workplace safety protocols in manufacturing hubs in Nigeria.

In this study, the major cities in Nigeria most populace states were sampled, namely Logos city of Lagos state and Port Harcourt city in Rivers state. The most populous city in Nigeria, is a bustling hub of industrial activity, encompassing a diverse range of sectors including manufacturing, oil and gas, telecommunications, and financial services. (Ogundare, 2020) The city's industrial diversity presents a unique opportunity to assess the implementation and impact of emerging safety technologies across different sectors. However, Lagos also faces significant

workplace safety challenges, driven by rapid industrialization, a high population density, and varying levels of regulatory compliance. (Afolabi et al., 2018). These factors combine to create a complex environment where the effectiveness of safety technologies can be critically evaluated. Port Harcourt, a critical hub for Nigeria's oil and gas industry, presents both opportunities and challenges in workplace safety. The hazardous nature of the oil and gas sector, coupled with the presence of other high-risk industries such as manufacturing and logistics, underscores the importance of adopting advanced safety technologies to protect worker (Nwankwo et al., 2020). The regulatory environment in Port Harcourt plays a pivotal role in shaping the adoption and enforcement of these safety technologies. Previous studies have highlighted the prevalence of health risks among workers in oil and gas facilities, stemming from factors such as the high toxicological qualities of oil and gas components and the complex nature of exploration, extraction, and processing (Attih et al., 2022).

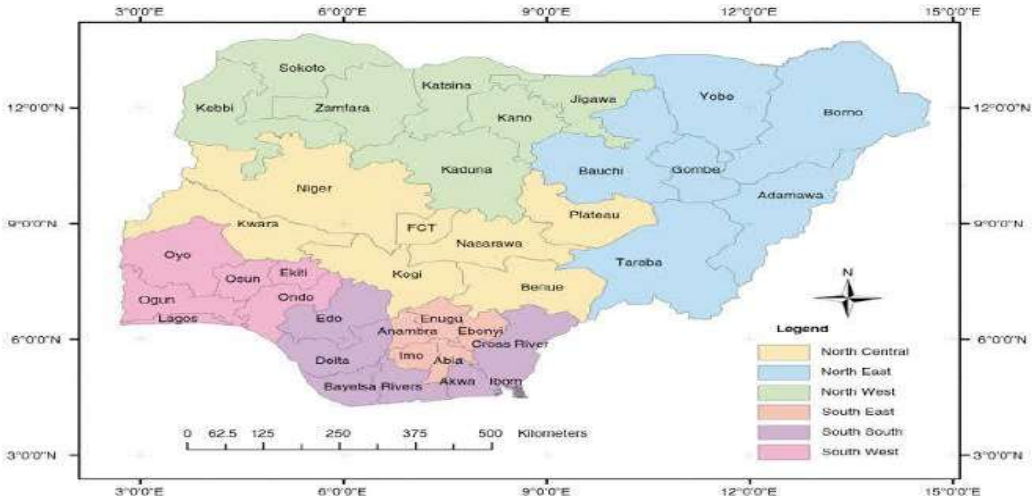

Figure 1: Map of Nigeria showing Lagos and Rivers State Source: Ayantoyinbo and Adepoju (2018)

2.3 Population of the study

The population of this study comprises manufacturing industries where workplace safety protocols and emerging safety technologies are critical. Given the relevance of safety in the manufacturing sector, a significant proportion of the firms in this sector are likely to require and implement advanced safety measures. Specific data for Lagos and Port Harcourt is limited; however, the Nigerian Bureau of Statistics (NBS) reported that, as of 2018, there were approximately 11,543 manufacturing establishments across Nigeria. Lagos, as the country's commercial hub, and Port Harcourt, known for its dominance in the oil and gas sector, host a substantial number of these establishments. Based on industrial activity concentration, it is reasonable to estimate that around 5,000 companies in these cities operate in sectors requiring robust workplace safety measures.

2.4 Sampling technique and sample size determination

The study adopts a stratified random sampling technique to ensure adequate representation of various facets of manufacturing sector across the sampled states selected for the study. Stratified sampling was chosen in this study because it allows for proportional representation of establishments based on their size. The stratification was done across two states sampled, with further segmentation into different manufacturing firms. After stratification, a simple

random sampling method was employed to select the actual participants within each stratum. This approach minimizes bias and enhances the generalizability of the findings. The sample size was determined using Taro Yamane's formula are presented in ~~e~~ Equation (1) below.

The sample size was determined using Taro Yamane's formula are presented in ~~e~~ Equation (3.1) below.

$$n = \frac{N}{1+N\times(e^2)} \quad (1)$$

Where: n is the sample size, N is the population size, and e is the sampling margin of error (0.05). based on the population size of 5000 and e is the sampling error (0.05)

Substituting into equation: $n = \frac{5{,}000}{1+5000\times(0.05^2)}$

n = 312.5≈ 313

However, 10% of the sample size which is 32 is added to the sample size to cover for possible non-returned and incorrectly filled question during the survey process. Therefore, the sample size for the study is 345

2.6. Nature/Sources of Data – Primary/Secondary

The study utilized both primary and secondary data sources to ensure a comprehensive analysis: Primary Data: Data was collected through structured questionnaires distributed among safety managers, compliance officers, and operations personnel from the sampled companies.
Secondary Data used in this study were relevant literature, industry reports, regulatory documents, and previous research studies were reviewed to provide contextual insights and support the primary data findings. These secondary sources were obtained from journal articles, safety compliance reports, and publications from international regulatory bodies.

2.7. Methods of Data Collection and Instrument

To assess the adoption of emerging technologies for workplace safety protocols, a survey data collection approach was employed. The survey focused structured questionnaire designed based on 5-point Likert-scale (Strongly Agree was assigned 5, Agree assigned 4, Neural assigned 3, Disagree assigned 2 and Strongly Disagree assigned 1) with critical threshold of 3.00. The questionnaire is subdivided into five main section; namely; Section A, which contain the socio-demographic of the sampled respondents in the sampled manufacturing firms across the study areas, Section B, which contain questionnaire items used to operationalize the response of the respondents on the level of adoption of emerging technologies for workplace safety in the sampled manufacturing firms. Section C contains questionnaire item on the level of workplace safety in the sampled manufacturing firms This section is further subdivided into section C1, C2 and C3 to capture safety outcome based on rate of accident, safety behaviour based on safety compliance and safety participation. The questionnaire was distributed electronically, with follow-up reminders to ensure a high response rate, and validated through pre-testing. A total of three hundred and forty-five (345) questionnaires were served to respondents out of which three hundred and thirty (330) were completed and returned representing 97.97%. this formed the basis for data presentation, and questionnaire response analysis presented in the next section.

2.8 Method of Data Analysis

The data collected using demographic characteristics of the respondents were analyzed using descriptive statistics particularly percentage. Descriptive statistics based on percentage and weighted mean score (WMS) was used to analyses the questionnaire parts designed based on Likert scale. Thus, research objectives were fulfilled using descriptive statistics (percentage and weighted mean score) and linear regression analysis. The results were presented in Tables Statistical Package for Social Sciences (SPSS) was used for the analysis.

3.0 Results and Analysis

3.1 Sociodemographic Characteristics of the Study Respondents

Table 1, presents the results on sociodemographic characteristics of the study respondents in the manufacturing industries in Nigeria, On the age distribution of the respondents, the results revealed that majority of the workers covering 43.94% % were between 26-35, followed by workers who are between age 36 to 40 who covered 26.36% while the least are workers of over 40 years old who covered only 14.55%. These results revealed that most of the workers in manufacturing industries in Nigeria are young people. On gender distribution of the respondent, the results revealed that 95.03% of the workers sampled were males while only 6.97 were female. This result entailed that the manufacturing industry job in Nigeria is dominated by male workers. This could be attributed to the physical nature of manufacturing operations making it more attractive to male than female workers. On company size, the results showed that 44.55% and 34.54% of the manufacturing firms in Nigeria are small and medium scale firms which make 79.09% while only 20.91 are large scale firms. These results implied that majority of the manufacturing companies in Nigeria are Small and Medium Scale-SMEs while only a hand full of companies are large scale firms. On years of experience, the results revealed that most of the workers have 6 to 10 years of experience in their covering 44.24% followed by workers who have 11-15 years of experience covering 25.15% while the least are workers who have 0ver 15 years of experience covering 12.73%. This means that most of the workers sampled in the manufacturing sector in Nigeria have substantial number of years of working experience in their various companies. Lastly, job status, the results revealed that most of the workers are safety officers covering 33.33, followed by supervisors covering 31.21% while the least are ground-level workers covering only 8.19% of the sampled workers

Table 1. Sociodemographic characteristic of the respondents in the Nigeria

Socio Demographics	Frequency (n=330)	Percentage (%)
Age		
18 – 25	50	15.15
26 – 35	145	43.94
36- 45	87	26.36
46 and above	48	14.55
Gender		
Male	307	95.03
Female	23	6.97
Company Size		
Small	147	44.55
Medium	114	34.54

Large	69	20.91
Years of Experience		
0-5	59	17.88
6-10	146	44.24
11-15	83	25.15
Above 15	43	12.73
Job Status		
Safety Officers	110	33.33
Operation Managers	90	27.27
Supervisors	103	31.21
Ground-Level workers	27	8.19

3.2 The level of adoption of emerging technologies for workplace safety in the manufacturing industries across Nigeria,

Table 2, showed the results of the descriptive statistics carried out to investigate the level of adoption of the emerging technologies for workplace safety in Nigeria, based on the response of the study respondents using weighted mean score. Eight questionnaire items were used to explore the opinion of the respondents of the level emerging technologies adoption specifically for workplace safety in their various manufacturing firms across the Nigeria, From the results it was observed that out of the eight questionnaire items capturing the level of adoption of emerging technologies for workplace safety in Nigerian manufacturing firms, the respondents agreed to only three items; 5^{th}, 7^{th} and 8^{th}, because their weighted means were greater than critical value 3.00, they disagreed on four item; 1^{st}, 2^{nd} 4^{th} and 6^{th}, because their weighted means were less than critical value 3.00 and undecided on one item. 3^{rd} because the weighted means is equal to critical value 3.00. These results suggest that the respondents disagreed to majority of the questionnaire items capturing level of adoption of emerging technology for workplace safety showing low level of adoption. However, the overall weighted mean score (WMS=2.94) which summarizes the eight questionnaire items is also less than 3.00 which confirmed that majority of the sampled workers in the manufacturing firms in Nigerian concurred to the notion that there is low level of adoption of emerging technologies for workplace safety in their various firms.

Table 2 level of emergency technologies adoption in manufacturing firms across Nigeria

S/N	Level of Emergency Technologies Adoption	SD.	D.	N	A.	SA	WMS	Remark
1	I currently use recent technology in my regular work for safety purposes	141.00 39.30%	31.00 10.47%	40.00 12.12%	42.00 13.87%	76..00 22.75%	2.61	Disagreed
2	Using technological equipment for safety purposes has become a routine for me in the workplace.	126.00 35.60%	40.00 12.12%	40.00 12.12%	58.00 18.06%	66.00 20.16%	2.69	Disagreed

3	A substantial part of the safety requirement for my daily work depends on the technology.	110.00 30.31%	20.00 6.60%	70.00 22.68%	20.00 6.60%	110.00 30.31%	3.00	Undecided
4	The daily safety of my work operations depends on the technology	75. 0 22.72%	51.00 15.45%	84.00 25.45%	120.00 36.36%	0.00 0.00%	2.75	Disagreed
5	I would gladly expand the use of the technology for safety purposes in my work activities	70.00 21.21%	30.00 9.09%	0.00 0.00%	200.00 60.60.%	30.00 9.09%	3.27	Agreed
6	I feel confident in using the technology for safety purposes in my workplace	160.00 48.48%	0.00 0.00%	0.00 0.00	115.00 34.85%	55..00 16.67%	2.71	Disagreed
7	My colleagues and supervisors encourage me to keep using the technology for safety purposes	30.00 9.09%	100.00 30.30%	0.00 0.00	130.00 39.39%	70.00 21.21%	3.33	Agreed
8	My safety outcome and productivity have noticeably improved due to the use of the technology	100.00 30.30%	30.00 9.09%	30.00 9.09%	70.00 21.21%	100.00 30.30%	3.12	Agreed
	Overall Weighted Mean Score						**2.94**	**Disagreed**

Note; SA is Strongly Agree, A is Agree, N is Neutral SD is strongly Disagreed, D is Disagreed, WMS is Weighted Mean Score

3.3 The level of workplace safety in the manufacturing industries across the selected countries

The level of workplace safety in the manufacturing industries was captured using safety performance expressed as safety outcomes as well a safety behvioour captured using safety compliance and safety participation. The results of the descriptive statistics carried out on the response of the study respondents based on weighted mean scale for the workplace safety operationalize using the aforementioned variable are presented below.

3.3.1 level of safety outcome in the manufacturing industries across Nigeria.

Table 3 showed the results of the descriptive statistics carried out to ascertain the level of workplace safety captured using safety outcome in manufacturing firms operating in Nigeria, Five questionnaire items were used to explore the opinion of the respondents on the safety outcome of their various manufacturing firms across the Nigeria and it was observed that out of the five questionnaire items capturing the safety outcome of Nigerian manufacturing firms, the respondents disagreed to 1st and 2nd items, because their weighted means were less than critical value 3.00, they agreed on one item; 4th and 5th item, because the weighted mean was greater than critical value 3.00 and undecided on 3rd item because the weighted means is equal

to critical value 3.00. These results implied that the respondents are neutral or undecided no most of the questionnaire items which opined that there is good safety outcome in the manufacturing firms in Nigerian in terms of low accidents and near-miss occurrence, low level of lost time due to safety issues in their firms. Moreover, the overall weighted mean score (WMS=3.00) which summarizes the five questionnaire items is also equal to 3.00 which confirmed that the respondents are neutral and undecided on the level of safety outcome in the manufacturing firms in Nigerian

Table 3. Level of safety outcome in the manufacturing industries across Nigeria

S/N	Safety Outcome	SD.	D.	N	A.	SA	WMS	Remark
1	In the past one-year accident in my workplace has become less frequent	141.00 39.30%	31.00 10.47%	40.00 12.12%	42.00 13.87%	76..00 22.75%	2.61	Disagreed
2	In the past one year, near-miss in my workplace has reduces	126.00 35.60%	40.00 12.12%	40.00 12.12%	58.00 18.06%	66.00 20.16%	2.69	Disagreed
3	The number of lost time due to injuries in my workplace has drastically reduced.	110.00 30.31%	20.00 6.60%	70.00 22.68%	20.00 6.60%	110.00 30.31%	3.00	Undecided
4	The number of emergencies due to safety issues has reduced	0.00 0.00%	51.00 15.45%	84.00 25.45%	120.00 36.36%	75.00 22.75%	3.36	Agreed
5	The number of machines shot-downs due to safety issues has reduced	30.00 9.09%	100.00 30.30%	0.00 0.00	130.00 39.39%	70.00 21.21%	3.33	Agreed
	Overall Weighted mean						**3.00**	**Neutral**

Note; SA is Strongly Agree, A is Agree, N is Neutral SD is strongly Disagreed, D is Disagreed, WMS is Weighted Mean Score

3.3.2 level of safety compliance in the manufacturing industries across Nigeria

Table 4. showed the results of the descriptive statistics carried out to ascertain the level of safety compliance of the workers in manufacturing firms operating in Nigeria, Five questionnaire items were used to explore the opinion of the respondents on the safety compliance of workers in their various manufacturing firms across the Nigeria, and, it was observed that out of the five questionnaire items capturing the safety compliance of workers in the Nigerian manufacturing firms, the respondents agreed to 1st and 4th and 5th items, because their weighted means were less than critical value 3.00, and undecided on 2nd and 3rd item because the weighted means is equal to critical value 3.00. These results showed that the respondents agreed to most of the questionnaire items which opined that the safety compliance of the workers in the manufacturing firms in Nigerian is good in terms following safety rules and procedures as well as applying knowledge and attitude gains during safety training and drills. Moreover, the overall weighted mean score (WMS=3.21) which summarizes the five questionnaire items is also greater than 3.00 which confirmed that the respondents agreed that the safety compliance of the workers in the manufacturing firms in Nigerian is good

Table 4. Level of safety compliance in the manufacturing industries across Nigeria

S/N	Safety Compliance	SD.	D.	N	A.	SA	WMS	Remark
1	I always wear the required safety gadgets and PPEs in workplace	0.00 0.00%	51.00 15.45%	84.00 25.45%	120.00 36.36%	75.00 22.75%	3.36	Agreed
2	I always follow the lock-out and tag-out procedures without shortcuts	110.00 30.31%	20.00 6.60%	70.00 22.68%	20.00 6.60%	110.00 30.31%	3.00	Undecided
3	I report unsafe acts and conditions as soon as I observe or notice them in workplace	110.00 30.31%	20.00 6.60%	70.00 22.68%	20.00 6.60%	110.00 30.31%	3.00	Undecided
4	I adhere to all safety rules and procedures in workplace every time	30.00 9.09%	100.00 30.30%	0.00 0.00	130.00 39.39%	70.00 21.21%	3.33	Agreed
5	I attend and apply knowledge gain from safety trainings and safety drills in the workplace.	100.00 30.30%	30.00 9.09%	30.00 9.09%	70.00 21.21%	100.00 30.30%	3.12	Agreed
	Overall Weighted Mean Score						**3.21**	**Agreed**

Note; SA is Strongly Agree, A is Agree, N is Neutral SD is strongly Disagreed, D is Disagreed, WMS is Weighted Mean Score

4.1.6.3 level of safety participation in the manufacturing industries across Nigeria, China and USA

Table 5 showed the results of the descriptive statistics carried out to examine the level of safety participation of the workers in manufacturing firms operating in Nigeria, Five questionnaire items were also used to explore the opinion of the respondents on the safety participation level of workers in their various manufacturing firms across the Nigeria, and it was observed that out of the five questionnaire items capturing the safety participation of workers in the Nigerian manufacturing firms, the respondents agreed all the items, because their weighted means were greater than critical value 3.00, These results showed that the respondents agreed to most of the questionnaire items which opined that the level of safety compliance of the workers in the manufacturing firms in Nigerian is good in terms of voluntarily involving in safety-related activities such as advising co-workers on safety issues, mentoring junior workers on safety-related activities, taking speaking section during safety drills. Moreover, the overall weighted mean score (WMS=3.26) which summarizes the five questionnaire items is also greater than 3.00 which confirmed that the respondents agreed that the level of safety participation of the workers in the manufacturing firms in Nigerian is good

Table 5. Level of safety participation in the manufacturing industries across Nigeria.

S/N	Safety Participation	SD.	D.	N	A.	SA	WMS	Remark
1	I voluntarily and actively take part in toolbox safety talks in the workplace	75.00 22.75%	31.00 10.47%	40.00 12.12%	42.00 13.87%	141..00 39.30%	3.42	Agreed
2	I always volunteer for safety committee activities in the workplace	160.00 48.48%	0.00 0.00%	0.00 0.00	0.00 0.00%	170..00 51.52%	3.06	Agreed
3	I usually offer suggestion to improve safety in the workplace	0.00 0.00%	51.00 15.45%	84.00 25.45%	120.00 36.36%	75.00 22.75%	3.36	Agreed

4	I advise and mentor junior co-workers on safety practices in the workplace	30.00 9.09%	100.00 30.30%	0.00 0.00	130.00 39.39%	70.00 21.21%	3.33	Agreed
5	I participate in emergency drill activities and exercises when they are conducted	100.00 30.30%	30.00 9.09%	30.00 9.09%	70.00 21.21%	100.00 30.30%	3.12	Agreed
	Overall Weighted Mean Score						**3.26**	**Agreed**

Note; SA is Strongly Agree, A is Agree, N is Neutral SD is strongly Disagreed, D is Disagreed, WMS is Weighted Mean Score

3.4 The impact of emerging technologies adoption on workplace safety in the manufacturing industries in Nigeria

The impact of emerging technologies adoption on workplace safety performance was investigated using linear regression analysis. The variables of workplace safety which comprised of safety outcome (SO), safety participation (SP) and safety compliance (SC) are the dependent variables while level of adoption of emerging technologies (AET) is the independent variable.

Table 6 present the summary of the linear regression analyses carried out to examine the impact of emerging technology adoption on workplace safety using safety outcome, safety compliance and safety participation as indictors to operationalize workplace safety in manufacturing firms operating in Nigeria. The results revealed that estimate coefficient of adoption of emerging technology (AET) for the three workplace safety indictors were 1.198, 0.064 and 0.068. This means that increase in emerging technologies adoption by one unit would results to increase in safety outcome, safety compliance and safety participation by 1.198, 0.064 and 0.068 unit respectively which means that impact of adoption of emerging technology in Nigerian manufacturing firms is more in improving safety outcome followed safety participation and lastly safety compliance.

The R-square values of 0.745, 0.252 and 0.303 means that 74.5%, 25.2% and 30.3% change in safety outcome, safety compliance and safety participation respectively were as a results of change in level of adoption of emerging technology for workplace safety while the remaining percentages 25.5%, 74.8% and 69.7% were caused by other factors and variables that were not considered in this current study. lastly, the p-values of 0.000, 0.073 and 0.065 respectively suggest that adoption of emerging technology only have significant impact on safety outcome while its impact on safety compliance and safety participation are not significant. These results summarily entailed that adoption of emerging technology for workplace safety in Nigerian manufacturing firms significantly and substantially improved safety outcome of the firms whereas its improvement on safety behaviour of the workers in terms of safety compliance and safety participation is not substantially.

Table 6 Summary of linear regression for impact of adoption of emerging technology on workplace safety for manufacturing firms in Nigeria

S/N	Dependent Variables	Estimate Coefficient	R-square value	t-value	p-value
1	Safety Outcome (SO)	1.198	0.745	4.156	0.000
2	Safety Compliance (SC)	0.064	0.252	1.023	0.073
3	Safety Participation) SP)	0.068	0.303	1.298	0.065

Significance level, p-value < 0.05

4. Conclusions

Based on the findings of this study on impact of emerging technologies adoption on workplace safety in manufacturing industries in Nigeria, the following conclusions can be drawn: one, there is low level of adoption of emerging technologies for workplace safety in Nigeria. Two, there is a moderate level of workplace safety in manufacturing firms operating in Nigeria manufacturing firms is moderate. Finally, the study showed that the adoption of emerging technologies has positive and significant impact on only safety outcome but not on safety compliance and safety participation. Conclusively, the study has shown that emerging technology adoption improved workplace safety moderately in developing countries like Nigeria. Hence, stakeholders in manufacturing sector in developing countries should provide infrastructure and regulatory framework required for adequate adoption of emerging technology for workplace safety in the sector.

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