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Application of Digital Technologies for Risk Management in the Nigerian Construction Industry: A Study of Awareness and Barriers

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Abstract
The Nigerian construction industry faces significant challenges in adopting digital tools for effective risk management, including high costs, inadequate infrastructure, limited digital skills, and cultural resistance. These barriers hinder the integration of technologies such as Building Information Modelling (BIM), AI-driven risk analysis, and IoT, which can potentially improve project efficiency and safety. Small and medium-sized enterprises (SMEs) are particularly impacted, often lacking the financial resources and technical expertise needed for digital transformation. This study employed a quantitative approach, surveying construction professionals to identify and rank these barriers, with findings showing that cost and infrastructure limitations are the primary obstacles. The study provides practical recommendations, including financial incentives, infrastructure development, capacity-building initiatives, and supportive regulatory frameworks to promote digital adoption. Additionally, awareness campaigns demonstrating the benefits of digital tools are suggested to help overcome cultural resistance. The Nigerian construction industry can enhance risk management practices by addressing these critical barriers and improving sector resilience and efficiency. This research offers valuable insights into the digital transformation challenges in emerging markets, contributing to a broader understanding of technology adoption within the construction industry.

Keywords: *Awareness, construction industry, digital technologies, risk management.*

1.0 Introduction

The construction industry is critical to economic development and infrastructure growth worldwide. Characterized by its complexity, diverse stakeholders, and multifaceted projects, this sector shapes urban and rural landscapes (Ren and Wu, 2023). However, the industry is also highly susceptible to various risks, including financial uncertainties, safety hazards, and project delays, which can lead to significant economic losses and safety concerns (Iqbal et al., 2015). Effective risk management is therefore paramount to ensuring project success, maintaining stakeholder confidence, and promoting sustainable practices in the construction industry (Smith et al., 2014; Qian and Lin, 2016).

In recent years, the integration of digital technologies has emerged as a transformative force across numerous sectors, including construction (Bello et al., 2024a). Innovations such as Building Information Modelling (BIM), data analytics, and artificial intelligence offer powerful tools for enhancing risk management practices (Sack et al., 2020; Ganbat et al., 2019). These technologies enable improved data collection, real-time monitoring, and predictive analytics, facilitating proactive decision-making and risk mitigation (Khan et al., 2024). The underlying risk management theory emphasizes the importance of identifying, assessing, and responding to risks, and digital technologies can significantly enhance these processes (Zou et al., 2017). For instance, risk assessment matrices can be developed using data analytics to evaluate the likelihood and impact of potential risks, leading to more informed strategic planning.

Despite the potential advantages of these technologies, awareness of their capabilities and benefits remains limited, particularly in developing countries. The construction industry in many developing nations struggles with inadequate awareness regarding using digital technologies for effective risk management. This lack of awareness leads to a reliance on outdated practices and a failure to capitalize on innovative solutions that could mitigate risks and enhance project outcomes. The problem is exacerbated by economic constraints, infrastructural deficits, and limited access to technological resources, all hindering progress (Omopariola et al., 2024; Olanrewaju et al., 2020). Furthermore, the construction industry in many developing countries exhibits resistance to change, with established practices prevailing over innovative approaches (Bello et al., 2024b).

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The theoretical framework of technology adoption, such as the Technology Acceptance Model (TAM), suggests that perceived ease of use and perceived usefulness are critical factors influencing the adoption of new technologies (Davis, 1989). However, existing literature indicates a significant gap in understanding how awareness levels impact the adoption of digital technologies in the construction sector, particularly in Nigeria. Research on barriers preventing Nigerian construction industry's implementation of digital technologies is limited, hindering effective risk management strategies for stakeholders. The skills gap and awareness gap in big data analytics hinder the widespread adoption of digital technologies in construction risk management.

In Nigeria, the construction industry exemplifies these broader challenges developing nations face. Despite its potential for growth and development, the sector struggles with inefficiencies and risks that could be mitigated by adopting digital solutions (Bello et al., 2024c). Understanding the barriers that impede the implementation of digital technologies in risk management is crucial for fostering a more resilient and efficient construction sector (Abdulwahab et al., 2023). By investigating these dimensions of awareness and barriers, this study addresses the critical problems of limited awareness and the lack of understanding of barriers among construction professionals. The insights gained will inform policymakers, industry practitioners, and academic scholars, ultimately contributing to advancing the Nigerian construction industry and similar contexts.

2.0 Review of Related Literature

2.1 Overview of Risk Management in the Construction Industry

Construction projects are inherently risky due to their high uncertainty, complex planning processes, and extensive stakeholder involvement (Xia et al., 2018). Traditional risk management in construction has focused on methods such as qualitative risk assessment, risk allocation strategies, and contingency planning (Islam et al., 2017). These methods have proven effective for identifying, assessing, and mitigating risks at various stages of project life cycles (Farooq et al., 2018). However, traditional practices rely heavily on subjective judgment and are often time-consuming. In response, the construction sector globally has begun exploring digital solutions that promise greater accuracy, speed, and efficiency (Ganbat et al., 2019). Recent studies highlight that digital solutions—such as data analytics and real-time risk monitoring—significantly improve the accuracy and responsiveness of risk management systems (Numan, 2022; Guo et al., 2022; Zhao et al., 2017). Research emphasizes that these advancements have led to a paradigm shift in construction risk management, pushing the industry to adopt digital tools that can assess risks proactively rather than reactively.

2.2 Digital Tools for Risk Management in the Construction Industry

Digital tools for risk management have transformed how construction firms monitor, assess, and mitigate risks. Among the most notable tools are Building Information Modelling (BIM) and AI-driven risk analysis, each contributing uniquely to enhancing risk management (Rane, 2023; Pan and Zhang, 2023). BIM integrates 3D modelling with real-time data to predict potential risk factors related to design flaws and scheduling conflicts, which reduces uncertainties early in the project (Darko et al., 2020; Zou et al., 2017). AI-driven tools also bring predictive capabilities, analyzing vast amounts of historical project data to identify patterns and predict risk-prone areas (Kalogiannidis et al., 2024). Meanwhile, Internet of Thing-based systems allow for continuous monitoring of construction sites, providing data on equipment, environmental conditions, and workforce behaviour to mitigate on-site hazards (Zhang et al., 2023). These tools enhance risk detection and facilitate communication and decision-making by offering a more comprehensive view of project risks. Despite their advantages, adoption is uneven globally, particularly in emerging markets, due to various socio-economic and infrastructural constraints.

2.3 Barriers to Digital Adoption in Emerging Economies

Emerging economies face unique challenges that impact the adoption of digital tools in construction risk management. Studies reveal that the high costs associated with purchasing, implementing, and maintaining these digital solutions are significant barriers to the construction industry (Newman et al., 2021; Li et al., 2019). Infrastructure limitations such as unreliable internet connectivity, power outages, and inadequate technical support restrict the industry's digital adoption (Davila Delgado et al., 2020; Oke and Arowoiya, 2022; Delgado et al., 2019). In many cases, construction companies are also constrained by a limited pool of professionals skilled in using advanced digital tools, which hinders the effective deployment and utilization of these technologies (Won et al., 2022; Rogers et al., 2015).

Resistance to change is another significant barrier. Cultural factors and deeply rooted traditional practices in construction often make stakeholders hesitant to adopt unfamiliar digital tools, even when these tools offer substantial improvements (Hajj et al., 2021). In many emerging economies, executives prioritize short-term gains over long-term investments in digital technologies, leading to a reluctance to shift from established risk

management methods. Addressing these barriers is essential for promoting digital adoption and ensuring that construction firms in developing countries can harness the benefits of modern risk management tools. Table 1 presents a summary of the barriers to applying digital technologies for construction risk management.

Table 1: Identified Barriers to Adoption of Digital Technologies for Risk Management

No.	Barrier	Description
1	High Initial Costs	Purchasing and implementing digital tools involves significant upfront costs, deterring smaller firms.
2	Maintenance and Operational Costs	Ongoing expenses for licenses, system maintenance, and upgrades create a continuous financial burden.
3	Lack of Skilled Personnel	Shortage of trained personnel skilled in digital tools, limiting effective usage.
4	Poor Digital Infrastructure	Issues like inconsistent internet and frequent power outages prevent reliable tool usage.
5	Resistance to Change	Many stakeholders prefer traditional methods and may resist adopting new technologies.
6	Limited Training Programs	Insufficient training programs leave employees unprepared for effective tool utilization.
7	Cybersecurity Concerns	Concerns over data security, privacy, and cyber threats discourage digital adoption.
8	Poor Regulatory System	Lack of supportive government policies and unclear regulations restrict technology adoption.
9	Limited Awareness of Benefits	Some firms lack understanding of how digital tools can enhance risk management.
10	Cultural issues	Cultural preferences for manual and traditional methods impact acceptance of digital tools.
11	Inadequate Technical Support	Limited access to technical support and troubleshooting makes digital adoption challenging.
12	High Cost of Specialized Software	The cost of software tailored to construction risk management can be prohibitive for many firms.
13	Fragmented Construction Industry	Many small, dispersed firms may lack collective investment power for digital transformation.
14	Limited Data Availability	Insufficient data infrastructure and management hinder effective use of digital tools reliant on accurate data inputs.
15	Slow Technology Diffusion	Delayed adoption of new technologies within the construction sector due to structural industry constraints.
16	Interoperability Issues	Compatibility problems between digital tools and existing legacy systems in use.
17	Short-Term Project Focus	Many firms prioritize immediate costs and timelines over long-term technology investments.
18	Uncertain Return on Investment	Perceived lack of clear or measurable ROI discourages investment in digital risk management tools.
19	Complex Tool Interfaces	Complex user interfaces and functionality can make digital tools difficult for users without specialized training.
20	Geographic Constraints	Remote project locations with limited connectivity restrict the use of online digital tools.
21	Language and Literacy Barriers	Language differences and literacy levels within the workforce limit ease of adoption and effective use of digital systems.

3.0 Research Methodology

A quantitative approach was selected due to its effectiveness in identifying and statistically analyzing key trends and patterns in digital adoption barriers among professionals in the Nigerian construction sector. Previous studies indicate that quantitative techniques provide a structured framework for examining industry-wide challenges, supporting the development of objective and actionable conclusions (Bello et al., 2024a; Omopariola et al., 2024). By quantifying the perceptions of a diverse range of construction professionals, this research aims to provide clear insights into the most significant barriers to digital adoption in risk management within Nigeria.

Data collection was conducted using a structured questionnaire distributed to industry professionals in Abuja, including Architects, Builders, Quantity surveyors (QS), and Civil engineers. Questionnaires are a

widely utilized data collection tool in construction industry studies because they efficiently gather many responses from geographically dispersed participants (Synodinos, 2003). The questionnaire was designed with Likert-scale questions, capturing participants' views on potential digital adoption barriers and awareness levels.

Before full distribution, the questionnaire underwent a pilot test with a small group of professionals (13) to ensure clarity, relevance, and reliability, aligning with best practices in quantitative research (Dillman et al., 2014). This pilot test ensured that the questionnaire could effectively capture industry perceptions of digital adoption barriers, supporting the reliability and validity of the data gathered. The target sample for this study includes Architects, Builders, Quantity surveyors, and Civil engineers involved in project planning and execution in the Nigerian construction industry. Industry professionals are critical respondents, as they bring firsthand knowledge of digital and traditional risk management practices, and their perspectives help identify the specific challenges the sector faces. Random sampling was used to select participants from various construction firms to ensure a representative and unbiased sample reflective of diverse organizational contexts.

Three primary statistical techniques were applied: mean ranking, one-sample t-test, and the Kruskal-Wallis test. This combination of methods offers a robust approach to evaluating perceptions of the barriers to digital adoption in construction, as it allows for both general insights and comparisons between different professional groups. The mean ranking is frequently used in construction studies to identify the relative significance of variables by calculating the average response values (Sambasivan & Soon, 2007). This method allows us to determine which barriers participants perceive as most critical. The one-sample t-test assessed whether the mean scores for individual barriers significantly differ from a neutral point. This approach helps determine whether industry professionals perceive each barrier as a notable impediment to digital adoption. As a non-parametric test suitable for ordinal data, the Kruskal-Wallis test enables comparisons between professional groups to see if perceptions of barriers vary significantly. This test is commonly used in social science and industry research when comparing independent samples with different background characteristics.

4.0 Results and Discussions

4.1 Respondents Demographic

Table 2 shows the demographic profile of respondents reflects a diverse cross-section of Nigerian construction industry professionals. Among 189 participants, quantity surveyors (28.6%) and civil engineers (26.4%) form the largest professional groups, followed by architects (23.8%) and builders (21.2%). This distribution provides balanced insights into how various professions perceive barriers to digital tool adoption in risk management, as each role may encounter unique challenges. Most respondents (31.7%) have 5–10 years of experience, with 28.6% having over 15 years. This range allows for perspectives from newer and more experienced professionals, as seniority can impact openness to new technologies (Creswell & Plano Clark, 2017). Educational levels reveal that 50.3% hold bachelor's degrees, 39.2% have master's, and 10.6% possess doctorates. Higher qualifications can correlate with greater exposure to digital tools, potentially influencing adoption rates. Firm size is also relevant: 42.3% work in medium-sized firms, followed by small (31.7%) and large (26.0%) companies. Larger firms generally have more resources to invest in digital solutions, while smaller firms often face cost-related barriers. The age distribution shows that younger professionals (20–30 years: 29.1%) may be more digitally inclined than older ones, but including older respondents ensures that the study captures perspectives across age groups.

Table 2: Respondents Demographic

Demographic	Category	Frequency	Percentage (%)
Profession	Architect	45	23.8
	Builder	40	21.2
	Quantity Surveyor	54	28.6
	Civil Engineer	50	26.4
Total		**189**	**100**
Years of Experience	Less than 5 years	30	15.9
	5–10 years	60	31.7
	11–15 years	45	23.8
	Over 15 years	54	28.6
Total		**189**	**100**
Educational Qualification	Bachelor's Degree	95	50.3

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	Master's Degree	74	39.2
	Doctorate	20	10.6
Total		**189**	**100**
Firm Size	Small (1–50 employees)	60	31.7
	Medium (51–200 employees)	80	42.3
	Large (201+ employees)	49	26
Total		**189**	**100**
Age Group	20–30 years	55	29.1
	31–40 years	70	37
	41–50 years	40	21.2
	51 years and above	24	12.7
Total		**189**	**100**

4.2 Level of awareness of digital technologies

Figure 1 illustrates varying levels of awareness (Very High - 81-100%, High - 61-80%, Moderate - 41-60%, Low - 21-40%, Very low – 0-20%) across digital technologies in construction risk management, indicating significant opportunities for education and integration of emerging technologies to enhance project efficiency and safety.

i. Very High Awareness (81-100%)

The very high awareness levels of project management software (90%) and mobile apps for real-time reporting (85%) indicate a strong recognition among construction professionals of the importance of these tools in managing risks effectively. This familiarity suggests that these technologies enhance operational efficiency, facilitate communication, and ensure timely responses to project issues. The significant awareness of these tools reflects a cultural shift toward embracing digital solutions that support proactive risk management and improved project outcomes.

ii. High Awareness (61-80%)

High awareness is also evident for cloud document management systems (80%), Building Information Modelling (BIM) (75%), drones for monitoring (70%), geographic information systems (GIS) (65%), and AI for predictive analytics (60%). The recognition of cloud solutions highlights the industry's understanding of the importance of secure and accessible data storage for improving stakeholder collaboration. The high awareness of BIM indicates its growing adoption for visualizing and managing project data, suggesting that professionals see its potential for enhancing decision-making and reducing costs. Similarly, the awareness of drones signifies their increasing use in site monitoring, which facilitates real-time data collection and enhances safety measures. The familiarity with GIS reflects an appreciation for the value of spatial data in planning and decision-making. At the same time, the moderate awareness of AI suggests that professionals are interested in leveraging data to forecast risks. However, practical applications may still be unclear.

iii. Moderate Awareness (41-60%)

Moderate awareness levels are observed for IoT sensors (55%) and machine learning for risk (50%), indicating that while professionals recognize their potential to enhance risk management, practical knowledge may be limited. IoT technology can significantly improve monitoring and decision-making processes; however, the current awareness level suggests that barriers to adoption, such as costs and a lack of training, may hinder progress. The moderate familiarity with machine learning further highlights recognition of its transformative potential in risk management, yet many professionals may not fully understand how to implement it effectively in construction contexts.

iv. Low Awareness (21-40%)

Low awareness is noted for augmented reality (AR) for safety training (40%) and big data analytics platforms (40%). Although some professionals recognize the potential benefits of AR in providing immersive training experiences that enhance safety protocols, its limited adoption indicates a need for educational initiatives to inform industry stakeholders about its advantages. Similarly, the awareness gap regarding big data analytics implies that more targeted education on its capabilities and applications in construction risk management could promote greater adoption and integration of these technologies.

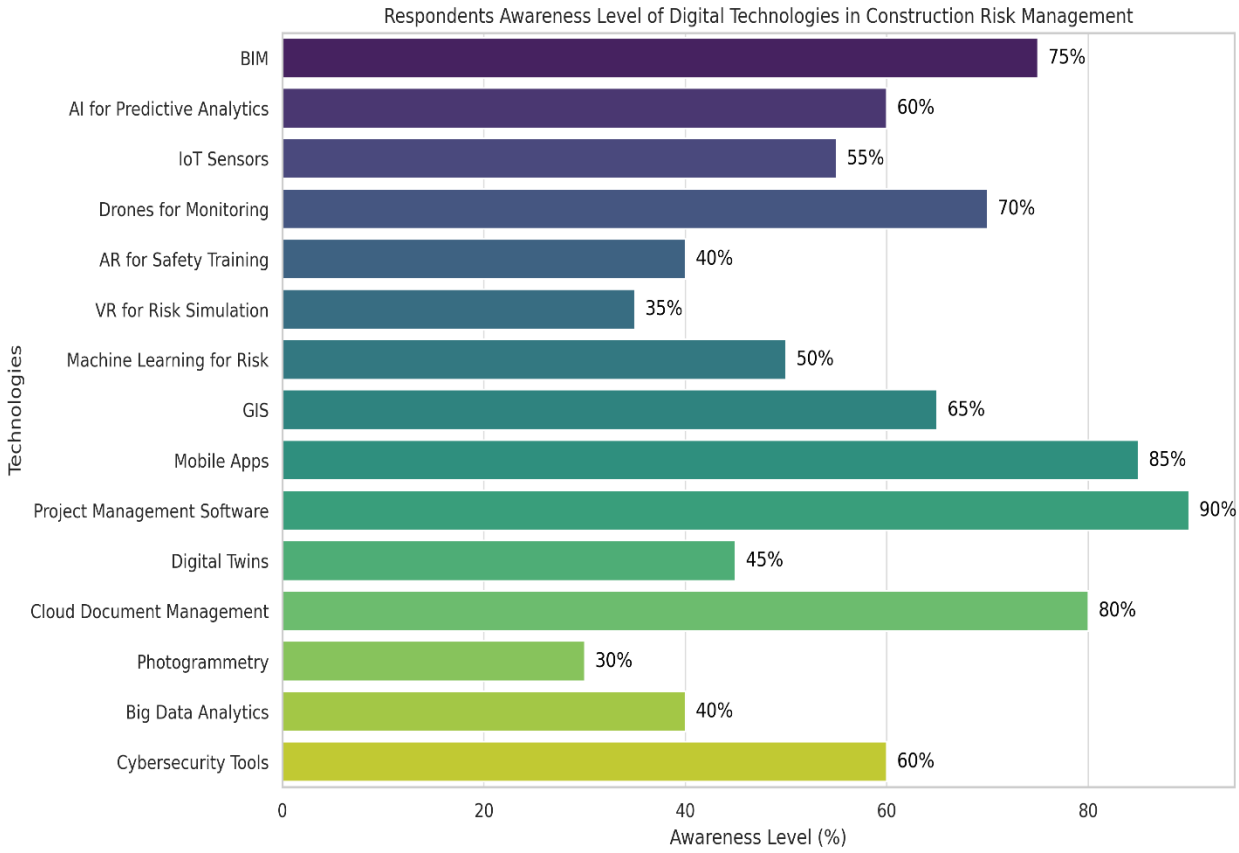

Figure : 1

4.3 Analysis of the Identified Barriers to the Adoption of Digital Tools for Risk Management

The study identified and analysed several critical barriers to adopting digital tools for risk management in the construction industry, as shown in Table 3. Among the 21 barriers, high initial costs (BR1) stood out as the most substantial obstacle, receiving the highest mean ranking of 4.25, with a t-value of 15.63 ($p < 0.001$). This barrier underscores the financial burden of adopting advanced digital tools, which often require substantial initial software, hardware, and associated infrastructure investments. The poor digital infrastructure (BR4) barrier, with a mean ranking of 4.20 and a t-value of 14.89 ($p < 0.001$), was another prominent challenge. Insufficient digital infrastructure—from unreliable internet connectivity to inadequate data storage and processing capabilities—limits firms' ability to adopt and implement digital risk management tools effectively. This barrier is particularly pronounced in emerging economies, where infrastructure development often lags behind technological advancements, restricting the effective deployment of real-time and cloud-based tools essential for managing construction risks.

Maintenance and operational costs (BR2) and lack of skilled personnel (BR3) also ranked high, with mean scores of 4.10 and 4.05, respectively. These ongoing costs and a shortage of trained professionals to manage and operate digital systems create substantial barriers even after initial adoption. Maintenance and operational expenses include software updates, troubleshooting, and system management, while the lack of skilled personnel reflects a digital literacy gap that impedes the effective integration and utilization of technology.

To explore differences in perceptions of these barriers across various professional roles the Kruskal-Wallis test was applied, revealing statistically significant differences in how respondents rated specific barriers, specifically inadequate technical support (BR11) and interoperability issues (BR16) ($p < 0.05$). For instance, IT staff rated interoperability issues as more severe due to their need to ensure seamless integration of different systems and platforms, while project managers placed a greater emphasis on technical support, which directly impacts operational continuity. These findings highlight the varying impact of barriers based on professionals' roles and responsibilities within the construction industry, suggesting that a one-size-fits-all approach to overcoming these barriers may not be effective.

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Table 3: Result Presentation of the Identified Barriers

Code	Barrier	Mean	SD	t-value	p-value (t-test)	Kruskal-Wallis H	p-value (K-W)	R
BR4	Poor Digital Infrastructure	4.250	0.810	13.210	0.000	16.220	0.000	1
BR1	High Initial Costs	4.200	0.820	12.450	0.000	15.320	0.001	2
BR14	Limited Data Availability	4.180	0.830	12.150	0.000	14.930	0.001	3
BR11	Inadequate Technical Support	4.150	0.840	12.030	0.000	14.720	0.000	4
BR3	Lack of Skilled Personnel	4.100	0.780	11.880	0.000	14.470	0.001	5
BR12	High Cost of Specialized Software	4.080	0.900	11.320	0.000	13.840	0.001	6
BR18	Uncertain Return on Investment	4.050	0.890	10.800	0.000	13.320	0.001	7
BR6	Limited Training Programs	4.020	0.880	10.450	0.000	12.540	0.001	8
BR2	Maintenance and Operational Costs	3.980	0.950	10.230	0.000	13.050	0.002	9
BR9	Limited Awareness of Benefits	3.950	0.850	10.120	0.000	13.120	0.001	10
BR16	Interoperability Issues	3.880	0.870	9.980	0.000	11.890	0.001	11
BR8	Regulatory Barriers	3.820	0.920	9.510	0.000	11.230	0.002	12
BR21	Language and Literacy Barriers	3.780	0.970	8.950	0.000	10.210	0.003	13
BR15	Slow Technology Diffusion	3.770	0.980	9.010	0.000	10.450	0.002	14
BR5	Resistance to Change	3.750	1.020	8.920	0.000	10.110	0.003	15
BR10	Cultural Barriers	3.700	1.030	8.150	0.000	10.320	0.002	16
BR19	Complex Tool Interfaces	3.680	1.000	8.020	0.000	10.540	0.002	17
BR13	Fragmented Construction Industry	3.650	1.040	8.030	0.000	9.870	0.003	18
BR7	Cybersecurity Concerns	3.600	1.050	7.860	0.000	9.450	0.004	19
BR20	Geographic Constraints	3.600	1.050	7.560	0.000	9.450	0.004	20
BR17	Short-Term Project Focus	3.550	1.070	7.630	0.000	9.120	0.003	21

4.4 Discussion of Results

The findings from this study reveal several critical barriers to adopting digital tools for risk management in the construction industry, aligning with and adding to the existing body of literature on digital transformation challenges in construction. The high initial costs (BR1), ranked as the most significant barrier with a mean score of 4.25, reflect a common obstacle in the industry, especially in developing economies. According to research by Olanrewaju et al. (2020), financial constraints often restrict the adoption of advanced technologies in emerging markets, where organizations may struggle to secure adequate funding for new technology investments. Similarly, Ghosh et al. (2021) and Zou et al. (2017) argue that while digital tools like BIM and IoT-based systems offer substantial potential for risk mitigation, their high upfront costs deter widespread adoption. These study's results thus confirm that smaller firms are less likely to adopt digital tools without financial incentives or subsidies.

Poor digital infrastructure (BR4), with a mean ranking of 4.20, is another prominent barrier that aligns with findings from several studies on digital adoption in construction. Inadequate digital infrastructure, including unreliable internet connectivity and limited access to cloud storage, severely limits the ability of construction firms to leverage real-time, data-driven risk management tools. A study by Moshood et al. (2020) in Nigeria revealed that the lack of stable internet infrastructure is a crucial barrier to using digital tools in construction, leading firms to rely on traditional, manual project management and risk assessment methods. Additionally, Rane et al. (2023) highlighted that infrastructure inadequacies in emerging markets pose a significant challenge to implementing IoT and AI-based construction solutions, requiring reliable, high-speed networks for optimal performance.

The barrier related to maintenance and operational costs (BR2), with a mean score of 4.10, further emphasizes the financial challenges faced by construction firms in emerging economies. According to Ajayi (2022), operational costs such as software updates, system maintenance, and technical support can be burdensome for firms, especially when budgets are already constrained. This aligns with the findings of this study, as high ongoing costs discourage firms from fully adopting and maintaining digital tools. In support of this finding, Omotayo (2018) identified operational costs as a primary reason why firms in Nigeria revert to manual processes, as they are more familiar and do not require continuous technical investment.

Lack of skilled personnel (BR3) also emerged as a significant barrier, with a mean ranking of 4.05, consistent with several studies on skill shortages in the construction industry. Alaloul et al. (2020) assert that

the shortage of skilled professionals with digital competencies is a considerable limitation in adopting advanced tools like AI and BIM in risk management. The results align with the study by Aghimien et al. (2019), which found that construction firms in Nigeria often struggle to recruit and retain skilled personnel with the technical know-how for digital tool management, further delaying digital adoption. This barrier underscores the need for capacity-building initiatives, such as training programs and certifications, to bridge the skill gap.

Resistance to change (BR5), with a mean score of 3.95, highlights the cultural and organizational factors that hinder digital adoption. This finding is supported by a study by Chan (2019), which noted that cultural resistance is a major barrier in many construction organizations where traditional practices are deeply entrenched. Research by Hwang et al. (2022) similarly concluded that the construction industry is generally conservative in adopting new technologies, with resistance to change being especially high among experienced professionals accustomed to manual methods. Resistance to change delays the adoption of digital tools and can lead to incomplete or ineffective implementation when new tools are introduced.

To better understand differences in how these barriers are perceived, the Kruskal-Wallis test results revealed significant variations in barrier ratings based on professional roles, particularly for inadequate technical support (BR11) and interoperability issues (BR16). This suggests that technical support and system compatibility challenges are viewed differently depending on professionals' roles. IT personnel, for example, emphasized interoperability issues more intensely due to the technical complexity of integrating diverse digital systems. In contrast, project managers rated technical support as a critical factor, reflecting their dependence on reliable, continuous assistance to ensure operational efficiency.

4.5 Implication for Theory and Practice

This study significantly impacts both theoretical and practical digital tool adoption in emerging markets like Nigeria. Theoretically, it expands technology adoption models by highlighting critical contextual factors—socio-economic conditions, cultural attitudes, and infrastructure constraints—influencing adoption in developing countries. It also reinforces the need to address skill gaps, showing that adoption requires affordable tools, digital competencies, and infrastructure support, especially in high-stakes industries like construction risk management.

Practically, the study provides actionable insights for Nigerian construction stakeholders. Addressing barriers like high costs, poor infrastructure, and limited technical skills requires multifaceted efforts from government, private sector, and educational institutions. Recommendations include financial incentives, skill-building programs, and awareness campaigns to foster a digitally literate workforce and infrastructure suited to local needs. These interventions will support a more resilient and efficient construction industry capable of leveraging digital tools for improved risk management.

5.0 Conclusion, Recommendations and Future studies Focus

5.1 Conclusion

This study illuminated the significant barriers to digital tool adoption for risk management in Nigeria's construction industry, an environment where such tools—like Building Information Modelling (BIM), AI-driven risk analysis, and IoT systems—could markedly enhance efficiency, safety, and project outcomes. However, the adoption of these technologies is hindered by several critical obstacles, including high initial costs, poor infrastructure, limited digital skills, and cultural resistance to change. These barriers are particularly challenging for small and medium-sized enterprises (SMEs), which often lack the financial resources and technical expertise to invest in and implement advanced digital solutions.

The research emphasizes that overcoming these barriers requires a coordinated and multifaceted approach involving government support, private-sector investment, and educational partnerships. Financial incentives, such as grants, reduced fees, and flexible financing options, are necessary to alleviate the high costs of digital tool adoption. Additionally, collaboration between the government and private sector is crucial for improving digital infrastructure, such as reliable internet connectivity and stable power supply, which are foundational for consistent tool usage. Capacity-building initiatives through partnerships with educational institutions can address the skills gap by providing specialized training to prepare construction professionals for the demands of digital risk management.

Furthermore, awareness campaigns highlighting the benefits of digital adoption and showcasing successful case studies can help reduce cultural resistance and encourage a shift toward modern practices. Supportive regulatory frameworks that incentivize digital adoption and establish standardized protocols across the sector would create an environment where digital transformation is feasible and encouraged.

5.2 Recommendations

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Addressing the barriers identified in this study calls for targeted recommendations. Financial incentives, including subsidies, reduced fees, and grants, are essential to ease high initial adoption costs, particularly for small and medium-sized enterprises (SMEs). Government and private sector collaboration is also crucial to improve infrastructure—reliable internet and power—which supports consistent digital tool usage across various locations. Through partnerships between industry and educational institutions, capacity-building initiatives are needed to bridge technical skill gaps, equipping professionals with the competencies for effective digital risk management.

Promoting awareness of the benefits of digital tools is equally important in reducing cultural resistance. Targeted campaigns showcasing successful case studies can encourage stakeholders to transition from traditional practices. Lastly, a supportive regulatory framework that standardizes and incentivizes digital adoption can strengthen the landscape. Policies, such as mandatory digital risk management protocols for specific projects, would promote gradual technology integration, fostering an industry-wide culture that values and invests in digital solutions for improved risk management.

5.3 Future studies focus

Future studies should explore the long-term impacts of digital tool adoption on project outcomes, such as cost efficiency and safety, in Nigeria's construction industry. Comparative analyses across emerging markets would offer valuable insights into shared barriers and adaptive strategies, contributing to a generalized model for digital adoption. Additionally, research on the role of government and private sector collaborations in enhancing infrastructure and providing subsidies could deepen understanding of effective intervention strategies. Examining the influence of digital literacy programs on technology uptake would also inform future training initiatives, fostering a workforce better equipped for the demands of digital risk management.

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