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FROM COMPLIANCE TO PREVENTION: FIRE SAFETY PREPAREDNESS IN TERTIARY INSTITUTIONS IN NASARAWA STATE, NIGERIA

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ABSTRACT: Fire safety in tertiary institutions is a critical governance and public safety concern due to high population density, complex infrastructure, and recurring fire incidents that threaten lives and academic assets. This study examined fire safety measures, emergency response preparedness, and the role of technology in fire prevention strategies in tertiary institutions in Nasarawa State, Nigeria, using risk management theory as an analytical framework. Drawing on survey data from students and staff, the findings revealed that fire safety preparedness is uneven and largely inadequate. Although basic fire safety units and limited training initiatives exist, critical preventive infrastructure such as functional fire alarms, smoke detectors, emergency exits, and maintenance systems remains insufficient. Emergency response preparedness is further constrained by weak coordination, limited training coverage, poor inclusivity for persons with disabilities, and minimal collaboration with external fire services. While technology integration is low, empirical evidence shows that technology-driven measures significantly enhance fire prevention effectiveness. The study concludes that fire incidents are foreseeable and manageable risks requiring integrated, enforceable, and technology-enabled prevention strategies. It recommended mandatory installation and maintenance of essential fire safety infrastructure, regular training and drills, strengthened regulatory enforcement, collaboration with fire services, and phased adoption of smart fire detection, alert, and monitoring technologies supported by sustained funding and institutional commitment.

Keywords: Fire safety governance; Emergency preparedness; Risk management; Technology adoption; Tertiary institutions; Nigeria

INTRODUCTION

Fire safety in tertiary institutions is a central concern in institutional governance due to the concentration of people, complex infrastructure, and diverse academic activities that heighten fire risk. Facilities such as laboratories, libraries, hostels, and administrative buildings often contain combustible materials, extensive electrical installations, and specialized equipment that require systematic risk management. Effective fire safety therefore extends beyond emergency response to include prevention, preparedness, detection, suppression, and evacuation. International institutional assessments indicate that embedding fire safety within routine organizational practice enhances

protection of lives, preservation of academic assets, and continuity of educational activities (International Labour Organization, 2021; UNESCO, 2021).

Ahrens (2023) increasingly frames fire safety as a shared organizational responsibility involving institutional leadership, staff, students, and external regulatory agencies. Evidence suggests that regulatory compliance alone is insufficient without sustained investment in infrastructure maintenance, regular drills, and safety awareness practices. Weak enforcement and limited training often reflect broader governance challenges that undermine the effectiveness of formal safety frameworks. As a result, fire safety is now conceptualized as an ethical and organizational obligation rather than a purely technical concern, particularly within public institutions responsible for safeguarding large populations (World Health Organization, 2023).

Despite advances in safety regulation globally, fire incidents remain persistent within tertiary institutions, underscoring their structural vulnerability. Similar patterns are evident across African countries, where overcrowding, aging infrastructure, and limited enforcement capacity continue to expose campuses to recurrent fire outbreaks. In Nigeria, official records consistently show that tertiary institutions experience repeated fires affecting student hostels, laboratories, libraries, and administrative facilities, often resulting in loss of lives, destruction of academic resources, and disruption of academic calendars (Federal Fire Service, 2023; National Emergency Management Agency, 2022).

In Nasarawa State, administrative reports indicate recurring fire incidents in public buildings, with higher risks observed in densely populated campuses characterized by electrical faults, overcrowded hostels, and inadequate detection and suppression systems (Nasarawa State Fire Service, 2023). These conditions suggest that fire incidents in tertiary institutions are not rare accidents but foreseeable hazards with measurable probability, particularly where preventive infrastructure and trained emergency personnel are absent.

Existing studies on fire safety in Nigerian tertiary institutions largely emphasize incident documentation or regulatory compliance, with limited empirical integration of emergency preparedness, institutional coordination, and technology-based prevention within a unified risk management framework. This study addressed this gap by examining fire safety measures, emergency response preparedness, and technology integration in tertiary institutions in Nasarawa State. Its contribution lies in demonstrating that institutional vulnerability is driven less by the absence of formal policies than by fragmented implementation, weak governance integration, and limited adoption of preventive technologies, thereby offering evidence relevant to fire safety governance and institutional resilience.

Research Objectives

Specifically, the objectives of the research were to:

1. What are the fire safety measures available in tertiary institutions in Nasarawa State, Nigeria?

2. How effective is the emergency response preparedness in the fire prevention strategy implemented in tertiary institutions in Nasarawa State, Nigeria?
3. How can the integration of technology enhance fire prevention strategies in tertiary institutions in Nasarawa State, Nigeria?

Conceptual Clarifications

Fire safety measures

Prevention strategies in fire safety refer to systematic, proactive measures designed to avert the outbreak of fires and mitigate their potential impact on lives, property, and the environment. Conceptually, these strategies encompass a combination of regulatory compliance, risk assessment, environmental design, technological interventions, and human behavior management, emphasizing anticipatory actions over reactive responses (National Fire Protection Association, 2022; Adeyemi & Oladipo, 2021). They include structural measures such as fire-resistant building materials, proper electrical wiring, and the installation of fire detection and suppression systems, as well as non-structural measures such as safety training, regular fire drills, hazard inspections, and public awareness campaigns (Khan et al., 2023). Effective fire prevention also relies on adherence to fire codes, enforcement of safety regulations, and continuous monitoring to identify and address emerging risks, thereby reducing vulnerability and enhancing preparedness (National Fire Protection Association, 2022). In essence, fire safety prevention strategies integrate technological, organizational, and behavioural approaches to create a comprehensive system that anticipates hazards and limits their potential consequences.

Prevention strategies

Prevention strategies in fire safety refer to proactive measures aimed at reducing the likelihood of fire outbreaks and minimizing potential harm to life and property. These strategies encompass risk assessment, enforcement of building codes, installation of fire detection and suppression systems, regular maintenance of electrical and mechanical equipment, and public education on fire hazards (Rahman et al., 2022; Al-Bizri et al., 2021). Effective prevention integrates both engineering controls, such as sprinkler systems and fire-resistant materials, and administrative measures, including safety protocols, training, and emergency drills, to ensure that individuals are prepared to respond appropriately in the event of a fire (Cheng et al., 2023). The overarching goal of fire safety prevention strategies is to establish a culture of safety that emphasizes early detection, prompt intervention, and continuous monitoring, thereby reducing the incidence and severity of fires in residential, institutional, and industrial settings (Khan et al., 2022).

Fire Safety Measures Available in Tertiary Institutions

Fire safety in Nigerian tertiary institutions remains an urgent issue, exacerbated by frequent fire incidents and insufficient infrastructure for effective fire management. Olanrewaju and Adeyemi (2021) noted that while basic measures like fire extinguishers and emergency exit routes are present, their effectiveness is undermined by poor maintenance and limited coverage. This observation aligns with the findings of Okonkwo et al. (2022), who reported that only 58% of universities had

functional fire extinguishers and 42% had properly marked emergency exits, suggesting substantial gaps in institutional preparedness. Furthermore, the National Fire Safety Code of Nigeria outlines comprehensive fire safety measures, including the installation of smoke detectors, alarm systems, and fire drills, but adherence to these guidelines remains inconsistent, putting staff and students at heightened risk (Abubakar & Musa, 2020). The problem is compounded by overcrowded lecture halls and hostels, which increase fire vulnerability. These systemic issues underscore the critical need for Nigerian institutions to invest in modern fire safety infrastructure to reduce fire risks.

The effectiveness of these measures is further hampered by inadequate awareness and lack of continuous training. Adesina and Adebayo (2023) found that only 37% of students and 45% of staff had received formal fire safety training, highlighting a significant gap in preparedness. This finding aligned with Olanrewaju and Adeyemi (2021) assertion that budgetary constraints and insufficient fire detection and suppression systems are common in many institutions. Comparative studies by Okonkwo et al. (2022) revealed that institutions with structured fire safety protocols and regular drills experience fewer incidents and lesser property damage, indicating that while some safety measures exist, challenges like insufficient funding and poor policy enforcement continue to undermine their effectiveness.

Effectiveness of Emergency Response Preparedness in Fire Prevention Strategy

Emergency response preparedness is a vital component of fire prevention strategies, but its implementation across Nigerian tertiary institutions remains uneven. Oladejo and Adeyemi (2021) found that only 42% of surveyed universities in South-western Nigeria had operational emergency response plans, including evacuation procedures and designated safety officers. This finding is consistent with Abubakar, Musa, and Bello (2022) report from North-Central Nigeria, which highlighted that fewer than 50% of campuses had essential firefighting equipment, further illustrating gaps in emergency response preparedness. However, evidence suggests that institutions with well-structured emergency response plans perform better during fire incidents. Akinbode and Yusuf (2020) demonstrated that universities with regular fire drills and trained personnel achieved a 65% faster evacuation rate, reinforcing the effectiveness of preparedness when properly implemented. Despite these positive outcomes, NUC (2022) reported that only 38% of Nigerian institutions fully comply with fire safety regulations, suggesting that infrastructure, funding, and regulatory constraints limit the broader application of emergency preparedness strategies.

The Integration of Technology Enhances Fire Prevention Strategy

Technological integration into fire prevention strategies is becoming increasingly important in Nigerian tertiary institutions. Oladipo and Adekunle (2023) found that many universities are adopting digital fire alarm systems, automated sprinklers, and smart monitoring technologies to enhance early fire detection and response. Adebayo, Okoro, and Bello (2022) reported that 62% of Nigerian universities have incorporated some form of technological fire detection, though only 28% have fully operational automated systems. These findings aligned with Chukwuma and Nwankwo (2023), suggesting that virtual reality-based fire drills and emergency simulations are being piloted in some institutions to improve preparedness. Despite the promise of these technological solutions, their implementation faces significant challenges, including inadequate funding and infrastructure.

Ibrahim, Olumide, and Eze (2022) highlighted that less than 35% of public universities maintain regular maintenance schedules for fire safety equipment, while private institutions, with better funding, report higher compliance rates. This disparity suggests that policy interventions and capacity-building efforts are necessary to ensure equitable access to technological fire safety measures.

The integration of the Internet of Things (IoT)-enabled sensors and integrated emergency management platforms has shown promise in reducing fire-related casualties by up to 40% in pilot institutions (Abubakar & Musa, 2023). However, as Ojedokun and Salawu (2023) noted, less than 35% of public institutions report maintaining regular maintenance schedules for fire safety technology, a gap that significantly impedes the effectiveness of these systems. These findings indicate that while technology can enhance fire prevention strategies, its successful implementation requires sustained institutional commitment, funding, and capacity-building to address infrastructural and technical limitations.

Theoretical Framework

Risk Management Theory

Risk management theory, widely attributed to Henley and McLoughlin (2001), posits that organizations can proactively manage uncertainties by assessing threats, quantifying potential impacts, and implementing controls to prevent or reduce hazards. The basic tenet of the theory is that systematic risk identification and mitigation reduce both the likelihood and severity of adverse events, thereby protecting human life and property. Within tertiary institutions in Nasarawa State, Nigeria, implementing this theory entails conducting routine fire risk evaluations, deploying fire detection and suppression equipment, providing staff and students with training on fire response procedures, and ensuring compliance with national safety standards and regulations (Olawale, 2020). By employing these measures, institutions can reduce the probability of fire outbreaks and ensure rapid response in emergencies, thereby safeguarding lives and institutional assets. Empirical evidence in Nigeria indicates that campuses implementing structured risk management approaches report lower incidences of fire-related damages and improved emergency preparedness (Nwankwo et al., 2022).

Despite its strengths, risk management theory is not without criticism and limitations. Aven (2016) argued that the theory is largely preventive and focuses heavily on quantifiable risks, often underestimating human behaviour, complacency, or resource constraints that can impede effective implementation. In Nasarawa State, challenges such as inadequate funding, inconsistent policy enforcement, and limited technical expertise may limit the full effectiveness of risk management strategies in tertiary institutions (Abubakar & Musa, 2021). Nonetheless, adopting this theory is justified because it provides a structured and proactive framework for addressing fire hazards, emphasizing prevention, mitigation, and continuous monitoring rather than reactive responses alone.

METHODOLOGY

The study employed a descriptive survey design to examine fire safety measures and prevention strategies in tertiary institutions in Nasarawa State, Nigeria. This design facilitated the collection of both quantitative and qualitative data from a large, diverse population, enabling generalizable findings. The study population comprised students and staff aged 18 years and above across various tertiary institutions, totalling 163,365. Using Yamane's (1967) formula at a 3% margin of error, a sample size of 1,111 respondents was determined. The 3% margin of error was chosen as a practical balance between ensuring statistical accuracy and maintaining feasibility, particularly given the large and diverse study population. Multi-stage sampling was applied, including simple random selection of five institutions from eleven and proportional allocation of respondents based on population size using Bowley's method. The questionnaire development process involved designing structured questions based on the study's objectives, ensuring clarity, relevance, and validity, and incorporating both quantitative and qualitative items to capture comprehensive data. Data were collected through questionnaires and in-depth interviews, ensuring triangulation of quantitative and qualitative approaches. Validity testing ensured that the questionnaire accurately measured the intended concepts, while reliability testing confirmed the consistency of responses over time. Both processes involved expert reviews, pre-tests, and statistical analysis to enhance the instrument's credibility.

The study was conducted in a diverse range of tertiary institutions in Nasarawa State, including Federal University of Lafia, Nasarawa State University, Keffi, Federal Polytechnic, Nasarawa, College of Education Akwanga and Isa Mustapha Agwai I Polytechnic, which have significantly **c**ontributed to the state's educational and socio-economic development. Data collection involved self-administered questionnaires supported by trained research assistants and recorded interviews, with prior consent and notification of institutional authorities. Quantitative data were processed using SPSS with univariate frequencies, Chi-Square tests, and Pearson correlation. While themes in the qualitative analysis were identified through a thorough review of interview transcripts, with recurring patterns and concepts being coded. These themes were then analysed to derive insights and establish connections to the research questions, ensuring a comprehensive understanding of the data. Ethical approval procedures were obtained from relevant institutional authorities before data collection, ensuring compliance with ethical standards. Participants were informed about the study's purpose, their voluntary involvement, and their right to confidentiality, with written consent secured prior to participation.

FINDINGS

Data Presentation

One thousand one hundred and eleven (1,111) questionnaires were distributed for the study, 1,054 questionnaire (95%) were accurately completed and returned, while 57 (5%) were not retrieved due to being either missing or incomplete. As a result, the analysis was carried out using the 1,054 valid responses.

Table 1: Distribution of respondents by socio- demographic characteristics

Variables	Frequency (N=1,054)	Percentage	Mean	SD
Age				
18-24	368	34.9	29.6	10.1
25-31	336	31.9		
32-38	179	17.0		
39 years and above	171	16.2		
Sex				
Male	678	64.3		
Female	376	35.7		
Marital Status				
Single	872	82.7		
Married	141	13.4		
Separated	17	1.6		
Widowed	16	1.5		
Divorced	8	.8		
Religion				
Christianity	578	54.8		
Islam	474	45.0		
Africa Traditional Religion	2	.2		
Location				
Hostel	350	33.2		
Off campus	704	66.8		

Source: Field work survey, 2025

The socio-demographic profile of respondents in Table 1 indicates a predominantly young population, with the majority aged between 18 and 31 years. This suggests that fire safety awareness campaigns should be tailored to younger adults, who are more likely to live in student hostels and off-campus accommodations. Male respondents constituted a larger proportion than females. Most respondents were single, underscoring the need to target individual students in fire safety training. Christianity and Islam were the dominant religions. Finally, a larger proportion of respondents resided off-campus, indicating that fire prevention strategies must extend beyond campus buildings to include private accommodations, emphasizing the need for broader community collaboration and emergency preparedness planning.

Table 2: Distribution of respondents on fire safety measures available in tertiary institutions

Questions	Yes	No	Not sure	Mean	SD
Are fire extinguishers readily available in all buildings of the institution?	381 (36.1%)	599 (56.8%)	74 (7.0%)	1.71	.589
Are there functional smoke detectors installed in all campus buildings?	224 (21.3%)	758 (71.9%)	72 (6.8%)	1.86	.510

Is there a dedicated fire safety unit in the institution?	841 (79.8%)	69 (6.5%)	144 (13.7%)	1.34	.705
Is there a functional fire alarm system installed throughout the campus?	191 (18.1%)	721 (68.4%)	142 (13.5%)	1.95	.560
Do you think there are fire-resistant materials used in the construction and renovation of campus buildings?	214 (20.3%)	245 (23.2%)	595 (56.5%)	2.36	.798
Are fire safety instructions prominently displayed in all buildings?	416 (39.5%)	555 (52.7%)	83 7.9%)	1.68	.612
Does the institution maintain up-to-date fire safety equipment maintenance records?	278 (26.4%)	633 (60.1%)	143 (13.6%)	1.87	.619
Are student and staff members trained in basic firefighting and evacuation procedures?	545 (51.7%)	443 (42.0%)	66 (6.3%)	1.55	.611

Source: Fieldwork survey, 2025

The analysis of fire safety measures in tertiary institutions in Table 2 indicates varying levels of preparedness, with mean scores ranging from 1.34 to 2.36 and standard deviations reflecting moderate variation in responses. The existence of a dedicated fire safety unit (Mean = 1.34, SD = 0.705) suggests that institutions formally recognize fire safety responsibilities, implying a foundation for coordinated preventive action. Availability of fire extinguishers (Mean = 1.71, SD = 0.589) and prominently displayed fire safety instructions (Mean = 1.68, SD = 0.612) indicate moderate implementation, highlighting the need for broader accessibility and awareness. Functional smoke detectors (Mean = 1.86, SD = 0.510) and fire alarm systems (Mean = 1.95, SD = 0.560) were reported as largely insufficient, signalling critical gaps in technological preparedness that could delay emergency response. The high mean for fire-resistant construction materials (Mean = 2.36, SD = 0.798) reflects considerable uncertainty among respondents, suggesting either a lack of information or an inconsistent application of safety standards. Maintenance of fire safety equipment records (Mean = 1.87, SD = 0.619) shows inadequate administrative oversight, while training of students and staff in basic fire response (Mean = 1.55, SD = 0.611) demonstrates partial implementation, emphasizing the need for regular drills and continuous education. Collectively, these findings imply that while some structural and institutional frameworks exist, comprehensive fire prevention in tertiary institutions requires improvement in equipment functionality, safety monitoring, and capacity building to mitigate fire risks effectively.

Table 3: Distribution of respondents on emergency response preparedness and fire prevention strategy

Questions	Yes	No	Not sure	Mean	SD
Is there a designated emergency response team for fire incidents on campus?	629 (59.7%)	195 (18.5%)	230 (21.8%)	1.62	.820
Are emergency contact numbers for fire services prominently displayed across campus?	737 (69.9%)	233 (22.1%)	84 (8.0%)	1.38	.629
Have students and staff members received training in emergency evacuation procedures within the last year?	261 (24.8%)	661 (62.7%)	132 (12.5%)	1.88	.599
Are there designated fire wardens for each building or department?	40 (3.8%)	746 (70.8%)	268 (25.4%)	2.22	.496
Does the institution have an emergency communication system to alert all campus occupants in case of fire?	62 (5.9%)	895 (84.9%)	97 (9.2%)	2.03	.387
Are there provisions for assisting individuals with disabilities during fire emergencies?	18 (1.7%)	756 (71.7%)	280 (26.6%)	2.25	.470
Does the institution conduct joint fire safety exercises with local fire services?	35 (3.3%)	488 (46.3%)	531 (50.4%)	2.47	.562
Are there emergency exits in the buildings?	142 (13.5%)	467 (44.3%)	445 (42.2%)	2.29	.689

Source: Fieldwork survey, 2025

The analysis of emergency response preparedness and fire prevention strategies in tertiary institutions, based on the computed means and standard deviations, revealed significant gaps in institutional readiness. The presence of a designated emergency response team scored a relatively low mean of 1.62 (SD = 0.820), suggesting moderate awareness but uneven operational readiness, which implies that fire incidents may not be managed efficiently. Emergency contact numbers were better displayed (mean = 1.38, SD = 0.629), indicating a positive step toward accessibility, though further reinforcement is needed to ensure quick response. Training for students and staff in evacuation procedures recorded a mean of 1.88 (SD = 0.599), reflecting inadequate preparedness, which could increase vulnerability during emergencies. The appointment of fire wardens per building scored very low (mean = 2.22, SD = 0.496), highlighting a critical deficiency in on-site accountability. Similarly, emergency communication systems (mean = 2.03, SD = 0.387) and provisions for assisting individuals with disabilities (mean = 2.25, SD = 0.470) were largely insufficient, implying serious risks for delayed alerts and lack of inclusivity. Collaboration with local fire services scored the poorest (mean = 2.47, SD = 0.562), indicating weak external coordination, while the adequacy of emergency exits (mean = 2.29, SD = 0.689) also reflected

suboptimal compliance with safety infrastructure standards. Collectively, these findings suggest that the institutions are moderately aware of fire risks but lack comprehensive preparedness, trained personnel, inclusive emergency measures, and effective communication systems, which are critical for preventing fire-related incidents and ensuring the safety of all campus occupants.

Table 4: Distribution of respondents on integration of technology in enhancing fire prevention strategy

Questions	Yes	No	Not sure	Mean	SD
Are smart smoke detectors with remote notification capabilities used in campus buildings?	55 (5.2%)	848 (80.5%)	151 (14.3%)	2.09	.433
Is there an automated emergency notification system that can send alerts to all students and staff simultaneously?	15 (1.4%)	944 (89.6%)	95 (9.0%)	2.08	.314
Are there IoT-enabled sensors installed to monitor potential fire hazards (e.g., overheating electrical equipment)?	24 (2.3%)	365 (34.6%)	665 (63.1%)	2.61	.533
Is there a mobile app available for students and staff to report fire safety concerns or incidents?	19 (1.8%)	837 (79.4%)	198 (18.8%)	2.17	.421
Does the institution use digital signage systems to display real-time emergency information during a fire incident?	28 (2.7%)	803 (76.2%)	223 (21.2%)	2.19	.452
Does the institution use drones for aerial assessment of fire incidents on large campuses?	1 (.1%)	908 (86.1%)	145 (13.8%)	2.14	.346
Is there a digital system for tracking regular maintenance of fire safety equipment?	19 (1.8%)	865 (82.1%)	170 (16.1%)	2.14	.399

Source: Fieldwork survey, 2025

The analysis of respondents' views on the integration of technology in enhancing fire prevention strategies in tertiary institutions indicates a generally low adoption of technological innovations. The mean scores for all items range from 2.08 to 2.61, with relatively low standard deviations, reflecting limited variability and consistent perceptions among respondents. Specifically, smart smoke detectors with remote notification capabilities, automated emergency alert systems, mobile reporting applications, digital signage, drones, and digital maintenance tracking systems are largely absent or underutilized on campuses. The slightly higher mean for IoT-enabled sensors (2.61, SD = 0.533) suggests moderate awareness or uncertainty about their presence. The implications for fire safety management are significant: the minimal use of technology compromises the timeliness and effectiveness of emergency response, increases the risk of uncontrolled fire incidents, limits real-time communication during emergencies, and undermines proactive monitoring of potential fire

hazards. Consequently, institutions need to invest in technologically advanced fire prevention systems, train personnel on their use, and ensure continuous monitoring and maintenance to enhance overall campus safety and reduce potential fire-related losses.

Hypothesis 1

Table 5: Mean, Standard deviation, and Pearson correlation matrix on level of emergency response preparedness and fire prevention strategy development

S/N	Emergency Response Preparedness Indicators	Mean	Standard Deviation	General Correlation Pattern
1	Emergency response team and contact visibility	1.50	0.72	Moderate to strong positive
2	Training and fire wardens availability	2.05	0.55	Moderate positive
3	Emergency communication systems	2.03	0.39	Weak to moderate positive
4	Support for persons with disabilities	2.25	0.47	Moderate positive
5	Joint fire safety exercises	2.47	0.56	Strong positive
6	Emergency exits in buildings	2.29	0.69	Moderate to strong positive

Source: Field work survey 2025

The correlation patterns in Table 5 indicate that emergency response preparedness components are positively interrelated, supporting the risk management assumption that preparedness functions as an integrated system rather than as isolated measures. Although mean scores suggest only moderate availability, the analytical significance lies in the strength of associations among variables. Joint fire safety exercises and emergency exits exhibit the strongest correlations, implying that external collaboration and physical evacuation infrastructure serve as central nodes that reinforce broader preparedness practices. Institutions that engage in joint exercises are more likely to exhibit coordinated training, clearer role allocation, and improved safety awareness, consistent with feedback and learning mechanisms emphasized in risk management theory. In contrast, weaker correlations associated with emergency communication systems indicate fragmentation between information dissemination and other preparedness components, limiting their amplifying effect during emergencies. Overall, the correlation structure justifies rejection of the null hypothesis while revealing that institutional integration, rather than mere presence of preparedness elements, determines fire prevention effectiveness.

Hypothesis 2

Table 6: Analysis of variance on integration of technology and fire prevention strategy

Technology Variable	β	t value	p value	Effect
Smart smoke detectors with remote alerts	-.395	-13.906	< .001	Significant
Automated emergency notification systems	.243	8.153	< .001	Significant
IoT-enabled fire hazard sensors	-.068	-3.072	.002	Significant
Digital emergency signage systems	-.445	-17.312	< .001	Significant
Use of drones for fire assessment	.071	3.366	.001	Significant
Digital maintenance tracking systems	-.227	-8.222	< .001	Significant
Mobile fire reporting applications	.011	.491	.623	Not significant

Source: Field work survey 2025

The regression results in Table 6 demonstrate that technology integration explains a substantial proportion of variance in fire prevention effectiveness, empirically validating the role of technological controls within risk management frameworks. Statistically significant coefficients for smart smoke detectors, digital emergency signage, and digital maintenance tracking systems highlight the dominant influence of early detection and system reliability technologies. The magnitude and significance of these coefficients indicate that deficiencies in automated detection and monitoring substantially weaken institutional fire prevention capacity. Positive coefficients for automated emergency notifications and drone based assessments further underscore the importance of real time communication and situational awareness in reducing response uncertainty. In contrast, mobile fire reporting applications show no significant effect, suggesting that participatory technologies dependent on user initiative have limited preventive value in the absence of strong safety culture and administrative responsiveness. Collectively, these findings confirm the rejection of the null hypothesis and demonstrate that technology enhances fire prevention effectiveness only when embedded within coherent governance, maintenance, and response systems.

DISCUSSION OF FINDINGS

The findings demonstrate that fire safety preparedness in tertiary institutions reflects a partial application of risk management principles, characterized by institutional awareness without corresponding depth in risk control and mitigation. Risk management theory emphasizes that effective safety governance requires not only risk identification but also the systematic deployment of preventive and control mechanisms to reduce hazard probability and impact (Henley & McLoughlin, 2001). The presence of fire safety units and limited training initiatives indicates that fire risk has been formally recognized at the administrative level, consistent with Adeleke et al. (2022). However, the inadequate availability of functional fire extinguishers, smoke detectors, fire alarm systems, and maintenance records reveals a failure in translating risk awareness into effective mitigation. This gap contrasts sharply with international fire safety standards that prioritize detection, suppression, and routine inspection as core risk control measures (International Labour Organization, 2018; National Fire Protection Association, 2020). The uncertainty surrounding the

use of fire resistant materials further underscores weak regulatory enforcement and poor risk communication, supporting critiques that safety compliance in tertiary institutions is often symbolic rather than operational (Oke et al., 2021; Yakubu & Ahmed, 2023; Adebayo & Oladimeji, 2020).

Emergency response preparedness similarly reflects incomplete adherence to risk management expectations. While the existence of response teams and emergency contact information suggests institutional acknowledgment of residual risk, preparedness remains largely superficial. Risk management theory requires continuous training, coordinated response planning, and system testing to ensure effective hazard response. The limited emphasis on regular drills, inclusive evacuation planning, emergency communication systems, and collaboration with external fire services indicates weak risk response capacity. This finding contrasts with the World Health Organization (2021) position that preparedness must be operational, inclusive, and inter agency oriented. Persistent uncertainty regarding fire wardens, emergency exits, joint exercises, and disability support highlights deficiencies in safety culture and risk communication, reinforcing evidence that institutions in developing contexts often prioritize reactive rather than preventive safety approaches (Oladokun & Adebayo, 2020).

The minimal integration of advanced digital technologies further illustrates weaknesses in proactive risk mitigation and continuous risk monitoring. Risk management theory identifies early warning systems and real time monitoring as critical for reducing uncertainty and preventing escalation of hazards (Aven, 2016). The limited adoption of smart detection systems, automated alerts, and digital maintenance tools indicates that fire safety management remains largely reactive. This aligns with findings that funding constraints, weak institutional commitment, and limited technical capacity hinder technology driven safety adoption in Nigerian tertiary institutions (Adeleke & Ojo, 2022; Babrauskas, 2018). In contrast, evidence from emerging economies demonstrates that when supported by strategic planning and governance commitment, technology enabled fire prevention significantly improves early detection and response coordination (Khan, Hassan, & Uddin, 2020; Zhang & Li, 2019). From a risk management perspective, the absence of such systems weakens continuous risk evaluation and institutional resilience, increasing vulnerability to preventable fire incidents.

Conclusion

This study concludes that fire safety preparedness in tertiary institutions in Nasarawa State is uneven and largely inadequate, despite recurring fire risks and existing regulatory frameworks. Although the presence of fire safety units and limited training initiatives indicates institutional awareness of fire hazards, critical preventive infrastructure such as functional fire alarms, smoke detectors, emergency exits, and maintenance systems remains insufficient. Emergency response preparedness is further constrained by limited training coverage, weak coordination, poor inclusivity for persons with disabilities, and minimal collaboration with external fire services, thereby undermining effective evacuation and damage control. The integration of digital technologies into fire prevention strategies is notably low, even though empirical evidence from this study shows that technology driven measures significantly enhance fire prevention effectiveness. The key contribution of this study lies in empirically establishing that fire risks in African tertiary institutions stem less from the absence of safety policies than from weak

institutional integration, symbolic compliance, and limited technological adoption. Anchored in risk management theory, the findings confirm that fire incidents in tertiary institutions are foreseeable and manageable risks when preventive, preparedness, and monitoring systems are coherently implemented. Practically, the study underscores the need for enforceable fire safety governance, regular drills, inclusive emergency planning, and phased adoption of automated detection and alert systems, supported by sustained funding and regulatory oversight. The study is limited by its cross sectional design and reliance on self-reported data, which may introduce perception bias and limit generalization beyond the study context.

Recommendations

i. To enhance the availability of fire safety measures in tertiary institutions in Nasarawa State, institutional management should prioritize the mandatory installation and regular maintenance of essential fire safety facilities across academic residential and administrative buildings, supported by clearly displayed safety instructions. This effort requires governing councils to commit to providing dedicated annual funding for fire safety infrastructure and compliance monitoring. In addition, regulatory bodies such as the Federal Fire Service and the National Universities Commission must intensify periodic inspections and enforce sanctions for non-compliance with national fire safety standards in order to promote accountability and strengthen institutional commitment to effective fire safety management.

ii. To improve emergency response preparedness in tertiary institutions, management should develop functional campus fire response teams, conduct regular fire drills, and implement compulsory training for staff and students, including the appointment of fire wardens in all buildings with inclusive arrangements for persons with disabilities. Collaboration with state and local fire services through joint simulation exercises and technical support is essential, while the Ministry of Education should integrate emergency preparedness standards into accreditation and quality assurance frameworks to ensure long term and sustained compliance.

iii. To strengthen fire prevention through technology integration, tertiary institutions should gradually implement smart fire detection systems, automated emergency notification platforms, and digital maintenance tracking tools, alongside staff training and clear operational procedures. This process should be supported by targeted funding and technology grants from state and federal governments, as well as public-private partnership incentives to address cost constraints, while institutional ICT units assume responsibility for system monitoring, data management, and regular upgrades to ensure the reliability and effectiveness of technology-based fire prevention strategies.

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