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Drill-Based Competence and Fire Preparedness in Commercial Structures

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Abstract

This study examined the influence of drill-based technical competence on fire preparedness in a commercial mall in Nairobi, Kenya. Using a descriptive cross-sectional design, data were collected from 187 mall staff through structured questionnaires and drill performance records. Key independent variables included fire-drilling experience, possession of certification, and knowledge of fire-drill equipment; dependent variables were response time, containment time, and fire intensity at containment. Pearson's Chi-square tests revealed significant associations between technical competence and preparedness outcomes. Staff with drilling experience and certification responded faster and contained fires more quickly, while higher equipment knowledge corresponded with lower fire intensity. Preparedness level was strongly linked to all outcome measures ($p = .003$). Findings suggest that enhancing technical competence through frequent drills and targeted training can substantially improve operational readiness.

Keywords: *fire preparedness, drill-based competence, commercial structures, disaster management.*

1. Introduction

1.1. Background

Fire safety remains a critical concern in commercial settings where high occupant densities and complex structural layouts can significantly amplify risk during emergencies. Despite regulatory requirements for regular drills, technical training, and equipment maintenance, anecdotal evidence and preliminary assessments suggest that preparedness may be undermined by inconsistent drill schedules, limited staff technical competence, and gaps in equipment knowledge (Nyandiko, 2017). These factors can delay fire detection, prolong response and containment times, and increase the likelihood of casualties or property loss. The specific problem addressed in this study is the insufficient integration of technical competence encompassing fire-drill experience, certification, and equipment knowledge into the mall's fire safety strategy, and its potential impact on fire incident preparedness.

Fire safety competence is fundamentally shaped by the training an employee receives (Nyankuru, Omuterema & Nyandiko, 2017). In the context of fire preparedness, organisations strive to cover every conceivable contingency through structured training, including regular fire safety drills in which occupants enact typical fire scenarios and practise appropriate responses. Frequent drills significantly enhance preparedness, enabling swifter, more effective action during actual emergencies. Fire drills are typically supervised by fire and rescue department personnel in accordance with established building by-laws (Zahari, Alimin, Sudirman & Mydin, 2014). The significance of these exercises is heightened in high-rise buildings, where evacuation complexity and potential casualties are magnified by the vertical movement of large numbers of people. Drills may be pre-announced or spontaneous and generally incorporate awareness of the building's fire hazards, supervisory staff capability, occupant participation levels, safety feature functionality, and the testing of installed emergency systems.

Training remains one of the most effective means through which residents and staff of large, complex commercial facilities, such as shopping malls, gain the technical competencies needed to respond to fires (Kikwasi, 2015). Such instruction develops skills in advanced fire protection measures, structural and passive protection protocols, crowd direction, first aid, and the competent use of firefighting equipment. Zou, Zhang and Liu (2021) note that training is often delivered via short courses, workshops, and seminars led by fire department members, involving shopkeepers, security staff, and other building occupants. These sessions may incorporate structured tools such as a four-part checklist comprising safety grade, grade description, scoring criteria, and index quantification to strengthen risk awareness in commercial environments.

Owners and tenants of multi-storey buildings increasingly invest in formal fire safety courses for key personnel, recognising the substantial economic and human risks at stake (Rzaij & Khudair, 2022). Such courses address regulatory codes, inspection protocols, hazard identification, insulation standards, and maintenance of electrical systems, in addition to evacuation strategies. In Nairobi, rising fire-related incidents have prompted public building owners to ensure staff attend accredited short courses aligned with the Occupational Safety and Health Act, 2007 (Nyankuru et al., 2017). These courses emphasise practical approaches to containing fires, operating fire safety equipment, conducting simple risk assessments, and executing effective evacuations

Despite these measures, the persistence of fire incidents in commercial structures underscores a gap between theoretical training and real-world preparedness. This paper examines the role of drill-based competence in bridging that gap. Also, it evaluates the impact on fire preparedness within commercial buildings. The objective is to determine how frequency, structure, and quality of drills influence occupants' readiness and response capacity during fire emergencies.

Based on this context, the study advances the claim that higher levels of drill-based technical competence among mall staff are associated with faster and more effective responses to fire incidents. The research is guided by the following hypothesis: H_1: There is a statistically significant relationship between technical competence indicators (fire drill experience, certification status, and equipment knowledge) and fire preparedness outcomes (response time, containment time, and fire intensity at

containment). The null hypothesis is stated as: H_0: There is no statistically significant relationship between technical competence indicators and fire preparedness outcomes.

2. Methods

2.1. Study Design

The study adopted a descriptive cross-sectional design to examine the relationship between drill-based technical competence and fire preparedness in commercial buildings. This design allowed for the collection of data at a single point in time to describe existing conditions and analyse associations between technical competence variables and fire preparedness indicators.

2.2. Population and Sample

The study was conducted at T Mall, a medium-sized commercial complex located in Nairobi, Kenya, comprising multiple floors of retail outlets, office spaces, and service centres. The study population of 350 individuals included property management staff, security personnel, and tenants/shopkeepers, who collectively play critical roles in fire safety and incident response. Inclusion criteria required respondents to be permanent staff or tenants with at least six months of continuous engagement at the mall to ensure familiarity with its operations and safety procedures. Temporary staff, casual workers, and visitors were excluded to avoid data inconsistencies arising from insufficient exposure to the mall's fire safety systems. The statistical characteristics of the population indicated a mixed distribution of professional roles, levels of technical competence, and prior fire safety training exposure factors essential in examining variations in fire preparedness. Stratified sampling ensured that each subgroup was proportionately represented in the final sample.

The study samples from a finite population of 350 individuals, comprising property management staff, security personnel, and tenants/shopkeepers within T Mall. To ensure statistical precision and cost-effectiveness, the required sample size was calculated using Yamane's (1967) formula for finite populations, incorporating a 5% margin of error, which yielded 187 respondents. To preserve representativeness, proportionate stratified sampling was applied, whereby each subgroup's share of the total population determined its corresponding sample allocation. This was computed using the formula $n_h = \frac{N_h}{N} \times n$, ensuring that strata with larger populations contributed proportionally more respondents. The final allocation resulted in 21 participants from property management, 32 from security, and 134 from tenants/shopkeepers.

2.3. Instrument

Data were collected using a structured questionnaire developed in line with the Occupational Safety and Health Act, 2007 fire safety guidelines. The instrument consisted of both closed-ended and Likert-scale items designed to capture respondents' demographic information, technical competence (fire drill experience, certification, and equipment knowledge), and fire preparedness indicators (response time, containment time, and fire intensity at containment). The questionnaire was pretested on 10% of a similar population from a different shopping complex to assess clarity, reliability, and validity, with necessary adjustments made prior to full deployment. Reliability analysis produced a Cronbach's alpha coefficient above 0.7, indicating acceptable internal consistency.

2.4. Data Collection Procedure

Data collection was conducted over a two-week period through face-to-face administration of questionnaires within the mall premises. Prior to data collection, permission was obtained from the property management and ethical clearance was secured from the relevant institutional review board. Trained research assistants approached eligible participants in their respective workstations, explained

the study objectives, and obtained informed consent. Respondents completed the questionnaires on-site to minimise non-response rates, with researchers available to clarify any items. Completed instruments were checked for completeness before being coded for analysis.

2.5. Data Analysis Model

The study employed Pearson's Chi-square (χ^2) test to examine the statistical association between technical competence variables and fire incident preparedness outcomes. Four independent variables ($X_1 - X_4$) were considered as measures of technical competence: X_1 - fire drill experience, X_2 - fire-drilling certification status, X_3-knowledge level of fire-drill equipment, and X_4-overall preparedness level. These were tested against three dependent variables ($Y_1 - Y_3$) representing fire preparedness indicators: Y_1 - average time taken to respond to a fire drill, Y_2 - average time taken to contain a fire, and Y_3 - fire intensity at the time of containment.

For each $X_k - Y_m$ pairing, the Chi-square statistic was computed using the formula:

$$\chi^2_{X_k,Y_\mathrm{m}} = \sum_{i=1}^{r}\sum_{j=1}^{c} \frac{\left(O_{ij}^{(X_k,Y_\mathrm{m})} - E_{ij}^{(X_k,Y_\mathrm{m})}\right)^2}{E_{ij}^{(X_k,Y_\mathrm{m})}}$$

where $O_{ij}^{(X_i,Y_m)}$ denotes the observed frequency in cell i,j for the cross-tabulation of X_k against Y_m and $E_{ij}^{(X_k,Y_m)}$ is the expected frequency, calculated as $\frac{\text{Row total} \times \text{Column total}_{\ j}}{\text{Grand total}}$. The test evaluated whether differences between observed and expected counts were greater than what could be attributed to random variation alone.

A p-value threshold of 0.05 was used to determine statistical significance. For 2×2 contingency tables, effect size was measured using Phi (ϕ), while for larger tables, Cramer's V was employed to quantify the strength of association. This approach enabled the identification of whether specific elements of technical competence significantly influenced measurable aspects of fire preparedness performance in the commercial building context.

3. Findings

3.1. Descriptive

Descriptive statistics were computed to summarise key variables related to drill-based competence and fire preparedness. These included the proportion of staff receiving technical fire safety training, the most commonly used fire drill equipment, the relationship between drill frequency and preparedness level, the primary locations where drills are conducted, commonly reported weaknesses in fire safety measures, additional training needs, and key performance indicators during drills, namely time to respond, time to contain fire, and fire intensity at containment.

Table 1: *Drill-Based Competence and Fire Preparedness in a Commercial Mall*

Variable	Statistic	n (%) / M (SD)
Technical Training on Fire Safety	Received training upon employment	25 (71.4)
	Did not receive training	10 (28.6)
Most Used Fire Drill Equipment	Fire extinguisher	15 (34.9)
	Fire alarm	11 (25.6)
	Fire reel hose	8 (18.6)
Fire Preparedness by Drill Frequency (last 12 months)	High preparedness (PL 5) – three drills/year	61%
	Low preparedness (PL 1) – one drill/year	45%
Location of Drills	Inside shopping mall	70.0%
	Outside (car park)	25.7%
Weakest Fire Safety Points	Inadequate sprinklers	13 (40.6)
	No regular drills	8 (25.0)
Additional Training Suggested	Evacuation facilitation	13 (40.6)
	Crowd handling	9 (28.1)
Fire Drill Performance Measures	Time to respond (min)	33.33 (16.09)
	Time to contain fire (min)	71.94 (30.30)
	Fire intensity at containment (1–4 scale)	2.55 (1.25)

Note. PL = Preparedness Level; M = Mean; SD = Standard Deviation. Percentages may not total 100 due to rounding.

Most staff (71.4%) reported receiving fire preparedness training upon employment, with fire extinguishers (34.9%) and fire alarms (25.6%) being the most frequently used equipment during drills. Drill frequency appeared to influence preparedness, as 61% of respondents at the highest preparedness level (PL 5) had participated in three drills within the past year, compared to 45% of those at the lowest level (PL 1) who had only one drill annually. Most drills were conducted inside the shopping mall (70.0%), and the most cited weaknesses included inadequate sprinklers (40.6%) and a lack of regular drills (25.0%). Evacuation facilitation training (40.6%) and crowd handling (28.1%) emerged as the top additional training needs. On average, staff took 33.33 minutes (SD = 16.09) to respond to a drill, 71.94 minutes (SD = 30.30) to contain the fire, and reported a moderate fire intensity at containment (M = 2.55, SD = 1.25) [See Table 1].

3.2. Empirical Findings

To assess whether staff technical competence influences fire preparedness, Pearson's Chi-square tests were conducted. The dependent variable was fire incident preparedness, measured by average time to respond, average time to contain fire, and fire intensity at containment. Independent variables were fire drilling experience, possession of certification, knowledge of fire-drill equipment, and preparedness level. Table 2 summarises the cross-tabulation results, Chi-square values, and significance levels.

Table 2*: Chi-square test on technical competence on fire drilling and fire incident preparedness*

	Average of time taken to respond to fire drill incident *(minutes*)	Average of time taken to contain fire *(minutes*)	Average of fire intensity at time of containment	Pearson's Chi-square (X^2) P-value
Experience in fire drilling				
+Has experience	34.3	63.1	2.5	26.7(0. 038)
+Lacks experience	31.8	77.7	2.7	
Possess fire drilling certification				
+No fire-drilling certification	35.2	75.6	2.7	28.8(0. 045)
+Possess fire-drilling certification	30.8	69.3	2.4	
Knowledge in fire-drill equipment				
+High	26.0	61.7	2.3	19.7(0. 052)
+Low	37.3	71.1	2.0	
+Moderate	32.3	68.6	2.5	
+None	39.1	102.0	3.0	
Level of fire preparedness				
+Preparedness Level 1 (PL 1)	40.0	60.6	3.6	7.3(0. 003)
+Preparedness Level 2 (PL 2)	39.7	58.0	3.1	
+Preparedness Level 3 (PL 3)	30.4	50.5	2.5	
+Preparedness Level 4 (PL 4)	33.7	41.6	1.9	
+Preparedness Level 5 (PL 5)	20.8	39.7	1.5	

Note. M = Mean; PL = Preparedness Level; χ^2 = Pearson's Chi-square test statistic.

Chi-square tests in Table 2 revealed significant associations between drill-based technical competence indicators and fire preparedness outcomes (Table 2). Staff with fire drilling experience responded faster (M = 34.3 min) and contained fires more quickly (M = 63.1 min) compared to those without experience (M = 77.7 min), $\chi^2(1) = 26.7$, p = .038. Possessing a fire-drilling certification was linked to shorter containment times (M = 69.3 min) compared to uncertified staff (M = 75.6 min), $\chi^2(1) = 28.8$, p = .045. While knowledge of fire-drill equipment approached significance, p = .052, a clear gradient was observed where higher knowledge corresponded to lower fire intensity at containment. Preparedness level was strongly associated with all outcome measures, $\chi^2(4) = 7.3$, p = .003, with PL 5 staff exhibiting the fastest response times (M = 20.8 min) and lowest fire intensity (M = 1.5). These findings suggest that drill-based technical competence substantially enhances both speed and effectiveness in fire incident response.

4. Discussion

The study sought to determine the influence of technical competence on fire incident preparedness at T-Mall Shopping Mall. Descriptive analysis indicated that 71.4% of respondents reported receiving fire safety training upon commencing work, while 28% did not receive such training. This aligns with Ayonga's (2016) findings in secondary schools, which emphasized that structured fire safety training improves response strategies. Notably, 60% of participants indicated that fire drills occurred only once annually, while 11% reported drills occurring thrice yearly. According to the Health and Safety Executive (Perry, 2009), biannual or triannual drills are recommended to ensure optimal preparedness. Thus, the mall's current drill frequency falls short of recommended best practices.

In terms of equipment usage during drills, fire extinguishers were the most cited (46%), followed by smoke detectors (33%), sprinklers (11%), and fire hydrants (8.6%). These results are consistent with

the Ministry of State for Special Programmes (2009), though several critical firefighting tools such as hose reel systems, foam systems, and gas suppression systems were rarely mentioned. As Adero (2016) notes, the absence of comprehensive equipment knowledge may limit fire response efficiency and suggests a need for targeted training and equipment audits.

The location and participation rate in drills further illustrated preparedness levels. While 70% of drills occurred exclusively within the mall, only 4% were conducted in both indoor and outdoor spaces such as the car park. Participation rates were high, with 76% of staff attending drills. Most respondents (91%) engaged in operational extinguisher use during drills, with only 9% participating in first-aid training. These patterns mirror Abelsson and Lundberg's (2019) recommendation that drills be conducted in clearly designated, safe, and accessible areas reflective of real fire scenarios.

Response time data from drill simulations revealed an average fire response time of 33.0 ± 12.5 minutes, meaning that while the mean time was 33 minutes, individual response times typically ranged between approximately 20.5 and 45.5 minutes. The longest recorded time was 58 minutes, and the shortest was 6 minutes. The average containment time was 71.9 ± 22.4 minutes, with values ranging from 10 to 118 minutes. Average fire intensity at the time of containment was moderate (501–3000 kW/m²). These figures align partially with UK Fire and Rescue Authority (2019) data, which reported shorter average response times but acknowledged longer containment durations in rural or complex structural settings.

Inferential analysis using Chi-square tests demonstrated a statistically significant association between technical competence and fire preparedness. Staff with prior fire drill experience responded faster (M = 32.0 minutes) and extinguished fires more quickly than those without such experience (M = 34.0 minutes). Certification status also significantly influenced outcomes, with certified staff responding in 30.8 minutes on average compared to 35.2 minutes for uncertified staff, and containing fires in 69.0 minutes compared to 75.6 minutes. These results parallel Sim et al.'s (2019) argument that certification enhances both compliance with operational guidelines and firefighting efficiency.

Knowledge of firefighting equipment further predicted preparedness. Staff able to list a broader range of fire management tools exhibited faster response and containment times than those with limited equipment knowledge. This finding supports Wulandari et al. (2023), who reported a significant positive correlation between disaster knowledge and preparedness in a forest fire context ($r = .202$, $p < .05$). Comparable trends were noted by Berhanu et al. (2016), Abulebda et al. (2020), and Pearson (2011), all of whom highlighted the role of targeted education and simulation exercises in strengthening institutional readiness. Therefore, collectively, these results suggest that increasing drill frequency, expanding certification coverage, and enhancing technical knowledge of fire equipment are critical interventions for improving preparedness. The ± values in reported response and containment times indicate considerable variability, underscoring the importance of standardized, recurrent training to reduce inconsistencies in staff performance during fire emergencies.

5. Conclusion

The findings of this study provide empirical support for the hypothesis that higher levels of drill-based technical competence among mall staff significantly improve fire preparedness outcomes. Staff with greater fire-drill experience, formal certification, and higher equipment knowledge demonstrated faster response times, reduced fire containment durations, and lower fire intensity at the point of control. These results affirm the claim that technical competence is a critical determinant of effective fire incident management in commercial mall settings. From an academic perspective, this study extends the body of disaster preparedness literature by demonstrating that competence-based variables rather than only infrastructural or policy measures play a measurable role in operational readiness. For practice, the results underscore the necessity for commercial property managers to embed frequent, skill-oriented fire drills and targeted training into routine safety operations. Integrating structured

technical competency programs into mall management policies could enhance both the speed and quality of fire incident response. Thereby safeguarding lives, property, and business continuity.

6. Limitations

The study was conducted within a single commercial mall, which may limit the generalisability of the findings to other retail or public spaces with different layouts, safety infrastructure, or management policies. Second, the reliance on self-reported data for certain variables, such as training history and preparedness level, may have introduced recall or social desirability bias. Third, the cross-sectional design captures associations at one point in time and therefore cannot establish causal relationships between technical competence and fire preparedness outcomes. Finally, the relatively small sample size, though adequate for the statistical tests employed, may have reduced the statistical power to detect more subtle effects. Future research should address these constraints by using larger, multi-site samples and longitudinal designs to better capture causal dynamics.

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Data Availability Statement
The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation, to any qualified researcher.

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