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A Survey-Based Study on the Effectiveness of Firefighting Training Programs among Industrial Workers in India

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Abstract:
Fire safety training and preparedness are critical priorities across all industrial sectors, especially in developing economies like India, where high fire-related fatality rates persist despite a decline in incident frequency. This survey-based study critically evaluates the effectiveness of current firefighting training programs among industrial workers in India, focusing on the role of human factors, training methodologies, and the impact of immersive technologies. Employing a quantitative, descriptive, cross-sectional design, data were collected via structured questionnaires from 400 respondents across diverse industrial sectors, including Manufacturing, Energy/Power Plant, Healthcare, and IT/Commercial. Findings indicate that while a majority of respondents perceive training as effective in reducing fire risks (71.8%) and skills improvement (70%), pervasive systemic gaps undermine overall preparedness. Key deficiencies identified include the absence of regular refresher training (43.5% of trainee challenges), low management support (35.8% of trainer challenges), and a structural failure to integrate audit findings into training curricula (62% reported never incorporating audit findings). Although Virtual Reality (VR)/Augmented Reality (AR) training is widely adopted (72.8%) and highly perceived as effective (71.5% rated it better than traditional methods), statistical analysis showed no significant difference in effectiveness between VR users and non-users. These results confirm the necessity of overcoming cultural barriers, such as the perception that VR is "not considered necessary" (48.5%), and technical deficits like the lack of specialized staff (30%). The study concludes that current programs are structurally deficient and proposes an integrated, standardized national framework, which received overwhelming support (73.3%), to enhance accountability, promote continuous learning, and ensure industry-specific preparedness.

Keywords: Firefighting Training, Industrial Workers, Preparedness, India, Virtual Reality (VR), Human Factors, Performance-Based Training, Safety Culture.

1. Introduction

Effective firefighting training and preparedness are fundamentally crucial across all industrial sectors to minimize fire risks, protect lives and property, and ensure business continuity. In high-risk environments such as offshore platforms, refineries, oil and gas operations, and manufacturing facilities, fire risks pose significant dangers to personnel, equipment, and the environment. Effective training programs must equip employees with the necessary knowledge and skills not only to prevent fires but also to respond effectively during emergencies, thereby contributing to a safer work environment.

The global fire safety landscape presents a persistent challenge. Globally, fire incidents claim thousands of lives annually, resulting in billions of dollars in property damage. In India, the situation reflects a paradox: while data indicates that fire accidents declined from 20,377 cases in 2014 to 7,566 in 2022, fatalities associated with these incidents remained consistently high, registering 7,435 deaths in 2022 alone. This persistent mortality rate suggests that although the frequency of incidents is reducing, those that do occur are highly fatal, indicating systemic weaknesses in preparedness and emergency response quality.

Catastrophic industrial fires highlight these vulnerabilities repeatedly. Incidents such as the Jaipur Indian Oil Corporation depot fire in 2009, which caused 12 deaths, and the Delhi Anaj Mandi factory fire in 2019, which killed 43 workers, exposed poor compliance with fire codes, inadequate emergency exits, and insufficient preparedness. International comparisons further emphasize that India lags behind developed countries in integrating modern technologies, automated sprinklers, performance-based building codes, and advanced training. A crucial aspect of this problem is the central role of human factors and training gaps; studies show that panic, poor decision-making, and insufficient knowledge significantly influence negative evacuation outcomes. Traditional training methods like drills and lectures are often insufficient to replicate the complexity and stressors of real fire emergencies.

The persistence of high fatalities despite technological advancements and regulatory frameworks reveals the multidimensional nature of the fire preparedness problem. The central problem addressed by this study is the inconsistency and ineffectiveness of current fire preparedness strategies across industrial sectors, particularly in developing contexts like India, where rapid industrialization often outpaces regulatory and training capacity. This research aims to bridge the gap between policy, technology, and practice by situating human behavior and training at the core of fire preparedness discourse.

The significance of this study is fourfold: Academically, it integrates behavioral, technological, and organizational perspectives to expand the body of knowledge on fire preparedness. Practically, it offers empirically grounded recommendations to strengthen training programs in high-risk sectors such as oil and gas and construction. Policy-wise, it provides evidence to inform the revision of regulatory standards and mandatory training modules. Finally, at a societal level, it contributes to enhancing public safety, reducing casualties, and building community resilience against fire-related disasters.

2. Objective

Based on the critical need for robust, evidence-based training evaluations, the primary objective guiding this research is:

Evaluate the effectiveness of firefighting training methods on performance and safety across industries.

3. Literature Review

The literature review establishes the theoretical foundation and contextual landscape for evaluating firefighting training, addressing the evolution of regulations, contemporary training methods, the centrality of human factors, and sector-specific preparedness strategies. The review strategy prioritized systematic analyses, experimental studies, and policy critiques focusing on high-risk environments and developing nations, spanning from 2004 to 2025.

3.1 Evolution of Fire Safety Regulations and Standards

Modern fire protection codes have largely developed in reaction to catastrophic fire events rather than in anticipation of them, necessitating constant revision due to changing risk attitudes, technological advances, and lessons learned from past tragedies (Mamatha N. et al., 2023). The fire safety regulation system has improved over time regarding testing capability and what constitutes a regulation, but the proliferation of high-rise buildings, new materials, and construction technology requires constant revision of fire safety codes (Mamatha N. et al., 2023).

Globally, fire safety regulation is experiencing a seismic shift from fixed prescriptive regulations to a performance-based design (PBD) approach (Spinardi et al., 2025). This PBD approach allows for greater flexibility but introduces challenges for regulators due to an "expertise asymmetry," where regulators are often not as technically savvy as the fire safety engineers they monitor (Spinardi et al., 2025). Furthermore, reliance on fire resistance ratings derived from standardized furnace tests persists as a central regulatory tool, despite these tests being unrepresentative of real-world fire scenarios (Spinardi et al., 2024). This reliance on outdated standards hampers the uptake of first-principles fire safety engineering and new, optimized building solutions (Spinardi et al., 2024). Regulatory inconsistencies also present challenges; for example, in Brazil, state-level regulations have led to an array of administrations and inefficiencies, requiring harmonization into a cohesive national standard (Rodrigues et al., 2017). In England, the post-Grenfell context showed that stronger regulation and clearer national guidance are needed regarding the use of fire-related expertise in planning, as fire authority advice is sometimes ignored (Benso & Elsmore, 2022).

In the Indian context, the effectiveness of fire safety regulations is hampered by numerous challenges, including rapid urbanization, high population density, and weaker enforcement mechanisms (Kannan et al., 2025). Studies highlight that the fatalities and injuries in India arise from a confused and inconsistent level of safety (Kodur & Kumar, 2019). Researchers suggest an integrated framework that facilitates advancements in overall fire safety across four areas: fire protection components in buildings, regulations and enforcement, consumer awareness, and technology and resources (Kodur & Kumar, 2019). The lack of consistent enforcement leads to a "policy-practice gap," where regulations often fail to translate into effective preparedness (Kannan et al., 2025).

3.2 Firefighting Training Methods and Techniques

Training is recognized as a cornerstone of workplace safety in high-hazard industries, with effective safety training showing a strong positive relationship with the acquisition of safety knowledge and safer operational behaviors (Bęś & Strzałkowski, 2024). Specifically, effective safety training contributes to improvements in the use of personal protective equipment (PPE) during overhaul operations, correct operation of self-contained breathing apparatus (SCBA), and thorough PPE inspection practices (Smith et al., 2024).

Literature suggests that active learning methods—including discussions, gamification, demonstrations, simulations, and the use of augmented and virtual reality—yield the most effective results, with the greatest impact coming from combining multiple methods in a balanced way (Bęś & Strzałkowski, 2024).

The role of Virtual Reality (VR) and Immersive Technologies has become increasingly significant. VR uniquely simulates highly complex and dangerous settings, such as confined-space fires, which are difficult or unsafe to emulate in reality, thereby enhancing preparedness, choices, and operational safety (Grabowski & Jach, 2021). Systematic reviews confirm that VR-based training is promising, particularly for scenarios dependent on realism and complexity, such as search and rescue or commander decision-making (Wheeler et al., 2021). User studies of VR training for domestic fire safety demonstrate that combining theoretical instruction with immersive practice improves awareness and leads to lasting behavioral changes (Ubieto-Artur et al., 2025).

However, challenges persist regarding the full integration of VR. A SWOT analysis of VR training identifies strengths (safety, cost-effectiveness, multi-sensory experiences) but also threats, including the potential for physiological risks from repeated exposure and unsure abilities to transfer skills from VR to real-world contexts (Engelbrecht et al., 2019). Furthermore, training must account for the high physiological demands of firefighting, requiring the assessment of workload and duration intensity rather than solely focusing on ambient temperature replication during drills (Horn et al., 2019).

3.3 Human Factors and Behavioral Aspects in Fire Emergency Response

The study of Human Behaviour in Fire (HBiF) is essential, as it directly influences evacuation outcomes and life-saving measures (Haghani et al., 2024). HBiF research remains fragmented, with existing knowledge gaps in integrating behavioral decision-making processes into fire safety planning and evacuation modeling (Haghani et al., 2024). Human Factors Theory emphasizes how decision-making under duress, stress-induced cognitive overload, and coordination breakdowns frequently compromise fire evacuation outcomes (Sasangohar et al., 2020). Effective training, therefore, is not just about technical skills but also about preparing individuals to manage stress, make rational decisions under uncertainty, and work collaboratively during emergencies (Sasangohar et al., 2020).

Prospect Theory explains that people make decisions under risk and uncertainty based on psychological biases, such as risk perception and fear of losses, often leading to counterintuitive or irrational behavior during emergencies (Wang et al., 2021). Applied to urban rail transit fire scenarios, Prospect Theory helps model how decision-makers weigh potential casualties versus economic losses (Wang et al., 2021). Effective training must thus incorporate behavioral economics insights by designing drills and simulations that account for real-world risk perception and cognitive biases (Wang et al., 2021). While some models assume panic, research suggests that individuals tend to respond rationally and with a socially acceptable disposition in emergencies, rather than exhibiting irrational panic (Bayat, 2018). VR-based approaches are highly valued for studying behavior in fire, as they safely simulate evacuation scenarios, capturing critical behavioral data such as evacuation delays (often exceeding one minute), high anxiety scores, and the propensity to ignore visual and audio cues (de Lama et al., 2020).

Resilience Theory provides the conceptual grounding for evaluating preparedness as the holistic capacity of individuals and organizations to anticipate, absorb, adapt, and recover from adverse events (Dinić et al., 2023). At the organizational level, resilience—as demonstrated in complex settings like hospitals—is shaped by ethical values (human dignity, altruism, accountability, trust, and empathy) alongside planning and safety systems (Sahebi et al., 2021). Integrating social science perspectives is vital to enrich HBiF research by adding pre- and post-fire behavior dimensions (Kuligowski, 2017).

3.4 Industry-Wise Fire Preparedness Strategies

Industrial fires represent catastrophic risks, demanding sector-specific strategies. In India, industrial hubs in states like Gujarat, Maharashtra, and Tamil Nadu face disproportionately high fire risks due to the concentration of chemical and hazardous industries (Rathod et al., 2023). The private sector is identified as particularly vulnerable, ranking ninth in fire risk compared to government sectors ranked eleventh (Rathod et al., 2023). Preparedness assessments in the oil and gas industry, for instance, often demonstrate only moderate levels of fire emergency response readiness, necessitating systematic drills and program enhancements (Jatmika et al., 2024). Other critical sectors face unique challenges. Healthcare facilities in Srinagar, India, showed substantial gaps in fire safety awareness and preparedness among workers, underscoring the urgent need for targeted training interventions (Rather et al., 2024). Conversely, in long-term care institutions in Taiwan, the application of a defense-in-depth fire protection framework was shown to be essential for limiting loss of life and significantly limiting casualties during nighttime fires (Wu et al., 2023).

The increasing complexity of modern buildings has also prompted the development of digital solutions. Building Information Model (BIM)-based fire disaster management processes integrate static building information (e.g., fire escapes, structural elements) with dynamic real-time fire data (Kim et al., 2023). This BIM-linked application is designed to enhance situational awareness and significantly increase fire response and rescue task efficiency (Kim et al., 2023). Finally, community preparedness is identified as a vital component for successful disaster management, requiring adequate knowledge, motivation, and resources at the community level (Akhtar et al., 2021).

In summary, the literature highlights that while regulatory advancements and technology offer powerful tools for safety, the execution of preparedness ultimately hinges on addressing human factors, organizational culture, and the consistent, context-specific application of high-quality training methodologies. The systemic issues of fragmented approaches, inconsistent enforcement, and gaps in human behavioral integration form the research gap that this study, with its specific focus on the industrial landscape of India, seeks to address.

4. Methodology

The study utilized a quantitative research mode with a descriptive, cross-sectional design to systematically evaluate firefighting training effectiveness across diverse industrial sectors in India. This approach was selected for its objectivity, ability to test hypotheses rigorously across a large population, and providing measurable insights into training outcomes. The primary data collection instrument was a structured questionnaire, meticulously developed, refined through expert reviews, and validated via a pilot study yielding a high internal consistency reliability (Cronbach's Alpha = 0.883). A stratified random sampling method was employed to select a diverse and representative sample of 400 respondents, comprising operational firefighters, fire instructors, safety officers, workers, and management personnel, drawn from high-risk industrial sectors including Energy/Power Plant, Manufacturing, Construction, Healthcare, and IT/Commercial. Data analysis employed specialized statistical software, utilizing descriptive statistics to summarize key trends and inferential statistics, including Paired Sample t-tests, Independent Samples t-tests, One-Way ANOVA, Chi-square tests, and Factor Analysis, to examine relationships between variables and test the study's hypotheses regarding training effectiveness, VR impact, and challenges faced.

5. Results

The analysis of data collected from 400 respondents provided detailed insights into current firefighting training practices, the perceived effectiveness of modern technologies, and systemic challenges across industrial sectors. The sample comprised primarily participants from IT/Commercial (38.3%), Healthcare (21.5%), and Energy/Power Plants (16.5%). Notably, 66.5% of respondents possessed six or more years of experience, and a vast majority (73.3%) had directly participated in a real fire emergency at their workplace.

5.1 Training Effectiveness and Methods

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	How effective is training in improving your emergency response skills? & Do you believe training reduced fire risks in your workplace?	400	.680	.000
Pair 2	Have you been trained in handling fire extinguishers, hydrants, sprinklers, and alarms? & Do you receive refresher training after audits or inspections?	400	-.030	.554

The paired samples correlations indicate two distinct patterns. For Pair 1, there is a strong positive correlation ($r = 0.680$, $p < .001$) between perceptions of training effectiveness in improving emergency response skills and the belief that training reduces fire risks. This suggests that employees who feel more confident in their emergency response skills also strongly perceive a reduction in workplace fire risks. In contrast, Pair 2 shows a negligible and statistically non-significant correlation ($r = –0.030$, $p = .554$) between being trained in using fire safety equipment and receiving refresher training after audits.

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	How effective is training in improving your emergency response skills? - Do you believe training reduced fire risks in your workplace?	.02250	.94828	.04741	-.07071	.11571	.475	399	.635
Pair 2	Have you been trained in handling fire extinguishers, hydrants, sprinklers, and alarms? - Do you receive refresher training after audits or inspections?	-1.78250	1.09462	.05473	-1.89010	-1.67490	-32.568	399	.000

The paired samples test reveals contrasting outcomes. For Pair 1, the mean difference between perceptions of training effectiveness in improving emergency response skills and belief in reduced fire risks is very small ($M = 0.0225$) and not statistically significant ($p = .635$), indicating that employees view these aspects as largely aligned with no meaningful difference. However, for Pair 2, there is a large and highly significant negative mean difference ($M = –1.7825$, $p < .001$), showing that while many employees have been trained in handling fire safety equipment, they report receiving significantly fewer refresher trainings after audits.

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Which training method is most common in your organization?	Between Groups	.036	1	.036	.024	.878
	Within Groups	610.404	398	1.534		
	Total	610.440	399			
How effective is training in improving your emergency response skills?	Between Groups	.693	1	.693	.466	.495
	Within Groups	592.067	398	1.488		
	Total	592.760	399			
What is the duration of an average firefighting training session in your workplace?	Between Groups	.150	1	.150	.195	.659
	Within Groups	305.600	398	.768		
	Total	305.750	399			

The ANOVA results show that none of the three variables tested yielded statistically significant differences. For training method (F = 0.024, p = .878), training effectiveness in improving emergency response skills (F = 0.466, p = .495), and average training session duration (F = 0.195, p = .659), the p-values are all well above 0.05. This indicates that perceptions and outcomes related to fire safety training are consistent across groups, suggesting no significant variation in common training methods, perceived effectiveness, or session duration within the organizations surveyed.

Training frequency was high, with nearly 90% of respondents undergoing training at least twice a year (48.5% twice a year; 41.5% more than twice). Training duration was also extensive, with 49.8% reporting sessions lasting more than one day and 34% reporting full-day sessions.

Training Methods and Perceived Effectiveness: Online modules were the most common training method (38.8%), followed by a combination of methods (28%). A substantial majority rated training positively, with 71.1% finding it effective or very effective in improving emergency response skills, and 71.8% believing it reduced fire risks in their workplace. However, the Paired Samples t-test (Pair 1) for Objective 1 showed no statistically significant difference between the perceived effectiveness of training in improving emergency response skills and the belief that training reduced fire risks (t = 0.475, $p=0.635$). This indicated that Null Hypothesis H_{01} was accepted regarding this distinction. Similarly, One-Way ANOVA confirmed no significant difference in effectiveness scores across different training methods (F=0.024, $p=0.878$).

Practical Skill Gaps: Despite high overall positive perceptions, practical skill gaps were evident: only 58% of respondents reported being trained in handling all essential firefighting equipment (extinguishers, hydrants, sprinklers, alarms).

5.2 Impact and Adoption of VR/AR Technologies (Objective 2)

Independent Samples Test		
	Levene's Test for Equality of Variances	t-test for Equality of Means

		F	Sig.	t	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Have you used VR/AR or simulation-based firefighting training?	Equal variances assumed	1.262	.262	.546	398	.585	-.07156	.12661
	Equal variances not assumed			.554	193.584	.580	-.07050	.12555
How effective was it compared to traditional training?	Equal variances assumed	.405	.525	.178	398	.859	-.24229	.29058
	Equal variances not assumed			.181	194.457	.856	-.23882	.28712
Do you think VR should be adopted in high-risk industries (oil, pharma, energy)?	Equal variances assumed	.094	.759	.501	398	.617	-.19049	.32069
	Equal variances not assumed			.494	183.413	.622	-.19513	.32534

The independent samples test results show no statistically significant differences across groups for all three variables. For VR/AR training usage (t = 0.546, p = .585), its effectiveness compared to traditional training (t = 0.178, p = .859), and opinions on adopting VR in high-risk industries (t = 0.501, p = .617), the p-values are all well above 0.05. This indicates that respondents hold largely similar views regardless of group differences, suggesting consistent perceptions about the use, effectiveness, and future adoption of VR/AR-based firefighting training.

Crosstabs

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.536[a]	12	.484
Likelihood Ratio	12.243	12	.426
Linear-by-Linear Association	.120	1	.729
N of Valid Cases	400		

a. 5 cells (25.0%) have expected count less than 5. The minimum expected count is 1.15.

The Chi-Square test results indicate no statistically significant association between the variables under study (Pearson χ^2 = 11.536, df = 12, p = .484). Both the likelihood ratio (p = .426) and linear-by-linear association (p = .729) further confirm the absence of a meaningful relationship. This suggests that the distribution of responses across categories is largely independent. However, it is worth noting that 25% of the cells had an expected count below 5, which may slightly limit the robustness of the test results.

Adoption and Perception: A significant 72.8% of respondents reported having used VR/AR or simulation-based firefighting training. When compared to traditional training, 71.5% rated VR/AR as more effective (38% much more effective; 33.5% more effective). Respondents overwhelmingly supported the adoption of VR in high-risk industries (oil, pharma, energy), with 70.8% agreeing or strongly agreeing. Key benefits cited included increased engagement (39.5%) and cost-effectiveness (31%).

Statistical Impact and Barriers: The Independent Samples t-test for Objective 2 found no statistically significant difference between the perceived effectiveness of VR/AR versus traditional training among VR/AR users and non-users (t = 0.178, $p=0.859$). This led to the acceptance of Null Hypothesis H_{02}, suggesting that the statistical impact on preparedness was not significantly distinct from traditional methods when comparing groups.

Analysis of barriers revealed that the greatest impediment to VR adoption was the perception that it is “not considered necessary” (48.5%), followed by the “lack of technical staff” (30%). A Chi-Square test confirmed no statistically significant association between the type of barrier cited and the opinion on VR adoption (Pearson $\chi^2=11.536$, $p=0.484$), implying general resistance persists regardless of the specific obstacle.

5.3 Systemic Challenges

Factor Analysis

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.500
Bartlett's Test of Sphericity	Approx. Chi-Square	191.495
	df	1
	Sig.	.000

The factor analysis results show that the Kaiser-Meyer-Olkin (KMO) value is 0.500, which falls at the minimum acceptable threshold, indicating mediocre sampling adequacy. However, Bartlett’s Test of Sphericity is highly significant (χ^2 = 191.495, df = 1, p < .001), confirming that the correlation matrix is not an identity matrix and that the variables are sufficiently correlated for factor analysis. This suggests that factor analysis is appropriate, though the strength of interrelationships among variables is only moderate.

The analysis of challenges faced by trainers and trainees identified profound structural deficiencies, leading to the rejection of Null Hypothesis H_{03} (Factor Analysis and descriptive statistics supported the existence of significant challenges).

Trainee Challenges: The most significant hurdle reported by trainees was the absence of refresher training (43.5%), followed by training content "not being industry-specific" (31.8%).

Trainer Challenges: Trainers primarily cited lack of specialized modules (38%) and low management support (35.8%) as their main challenges.

Audit Integration Failure: A critical finding was the failure of organizations to integrate lessons from compliance checks: 62% of respondents reported that electrical or fire audit recommendations were **never** included in training feedback, and another 26.3% reported this happening rarely.

5.4 Support for Framework Improvement

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.630[a]	.397	.396	.92486

a. Predictors: (Constant), What improvements would make training more effective?

The regression model summary shows a moderately strong relationship (R = 0.630) between suggested improvements in training and support for framework improvement. The model explains about 39.7% of the variance ($R^2 = 0.397$) in the dependent variable, with an adjusted R^2 of 0.396, indicating good model stability. The standard error of estimate (0.925) suggests a reasonable level of prediction accuracy.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	224.567	1	224.567	262.541	.000[b]
	Residual	340.433	398	.855		
	Total	565.000	399			
a. Dependent Variable: Would you support a standardized national framework for industrial firefighting training?						
b. Predictors: (Constant), What improvements would make training more effective?						

The ANOVA results demonstrate that the regression model is highly significant (F = 262.541, $p < .001$), indicating that suggested improvements to training have a strong predictive effect on whether respondents would support a standardized national framework for industrial firefighting training. With a large proportion of variance explained, the findings highlight that employees' perceptions of needed improvements are a key determinant in shaping their support for policy-level standardization.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.488	.159		9.373	.000
	What improvements would make training more effective?	.624	.039	.630	16.203	.000
a. Dependent Variable: Would you support a standardized national framework for industrial firefighting training?						

The coefficients table shows that suggested improvements in training have a strong and significant positive effect on support for a standardized national framework (B = 0.624, β = 0.630, t = 16.203, $p < .001$). This means that as employees identify more effective improvements in training, their likelihood of supporting a national standardized framework increases substantially. The constant (1.488) indicates a baseline level of support even without suggested improvements, reinforcing that training enhancements further strengthen this support.

Oneway

Research Question	Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
How important is management involvement in fire safety training success?	Between Groups	230.148	4	57.537	61.603	000
	Within Groups	368.929	395	0.934		
	Total	599.077	399			
Does your organization integrate electrical/fire audit recommendations into training?	Between Groups	3.743	4	0.936	1.28	0.277
	Within Groups	288.817	395	0.731		
	Total	292.56	399			

The one-way ANOVA results reveal contrasting findings. For management involvement in fire safety training success, there is a highly significant difference between groups ($F = 61.603$, $p < .001$), indicating that management involvement plays a crucial role in determining training effectiveness. In contrast, for integration of electrical/fire audit recommendations into training, the results are not significant ($F = 1.280$, $p = .277$), suggesting that audit-based recommendations are not consistently influencing training practices across organizations.

Support for Standardization: An overwhelming majority (73.3%) of respondents supported or strongly supported a standardized national framework for industrial firefighting training.

Management and Accountability: Management involvement was deemed important or very important by 70.8% of respondents. Furthermore, 73.5% strongly supported linking fire safety training to employee performance appraisals.

Regression Analysis: Regression Analysis confirmed that perceived improvements in training effectiveness significantly predicted support for a standardized national framework (F=262.541, $p=0.000$, Beta=0.630). This result led to the acceptance of Alternative Hypothesis H_{14}, supporting the notion that a proposed framework significantly improves fire safety by being positively associated with perceived necessary improvements. One-Way ANOVA confirmed that this strong support for a standardized framework was consistent across different industrial sectors (F=0.195, $p=0.659$).

6. Discussion

The findings of this survey-based study reveal a complex and often contradictory state of firefighting preparedness among industrial workers in India, providing empirical evidence to support the argument that current strategies suffer from structural deficiencies and under-leveraged technological potential.

6.1 The Effectiveness Paradox and Structural Deficiencies

Despite high employee motivation (71.8%) and generally positive perceptions of training effectiveness (70% positive rating), the systemic quality of training is highly flawed. The acceptance of the Null Hypothesis H_{01} (no significant difference between perceived skill improvement and risk reduction) suggests that while employees value training, their assessment of its impact on objective outcomes may be minimal or subjective. This nuance is critical, indicating that training may be compliance-driven rather than performance-outcome oriented.

The rejection of H_{03}, validated by the high factor loadings (0.900) on a single component representing trainer and trainee challenges, highlights pervasive structural deficiencies. The core issues—lack of specialized modules (38%) and the absence of refresher training (43.5%)—are direct failures of planning and organizational commitment. Effective fire safety requires specialized courses tailored to unique industrial hazards, such as Class B fires in oil and gas or confined spaces. Without context-specific training, the workforce remains ill-equipped to handle the specialized dangers prevalent in high-risk sectors.

Most significantly, the finding that 62% of organizations never integrate audit findings into training reveals a catastrophic breakdown in the continuous improvement cycle. Audits are meant to identify weaknesses like expired extinguishers or poor signage; failing to feed these lessons back into training ensures that systemic risks persist and that training remains irrelevant to the actual workplace vulnerabilities. This constitutes a profound policy-practice gap that hinders organizational resilience.

6.2 The VR/AR Ambiguity: Bridging Perception and Statistical Impact

The high adoption rate of VR/AR (72.8%) and the strong perceived effectiveness (71.5% rated it better than traditional methods) align perfectly with the literature advocating for immersive technologies in performance-based training. VR's ability to simulate complex scenarios safely is invaluable in industrial contexts.

However, the finding that Null Hypothesis H_{02} was accepted (no significant difference in effectiveness between VR users and non-users) presents an ambiguity. This suggests that while VR is individually compelling and engaging, its current large-scale integration into industrial training may not yet translate into statistically measurable, sector-wide improvements in preparedness beyond what traditional methods achieve. This could be due to several factors cited in the literature and sources: issues with skill transferability from VR to reality, insufficient technical staff to develop and maintain high-fidelity, industry-specific VR modules, or the overriding cultural barrier that VR is "not considered necessary" (48.5%). The industry is embracing the tool, but the strategic integration required by Performance-Based Training Models to optimize outcomes is still maturing.

6.3 Mandate for an Integrated Framework

The overwhelming support for a standardized national framework (73.3%) and the highly significant regression finding (H_{14} accepted, $p=0.000$) confirm that stakeholders recognize the deficiencies in the status quo and demand a cohesive, enforceable system. This mandate provides the basis for developing an Integrated Fire Preparedness Performance Model (IFPPM).

Such a framework must be guided by Resilience Theory, focusing on anticipation, absorption, adaptation, and recovery, rather than just compliance. It must leverage Human Factors Theory by institutionalizing stress management and decision-making training, building on the observed high employee motivation. Crucially, the IFPPM must enforce the systematic closing of the audit-to-training loop, making management involvement and accountability (highly supported by 70.8% of respondents) mandatory and linking safety performance to appraisals (supported by 73.5%) to ensure safety becomes a core organizational value, as highlighted in the findings.

7. Conclusion

This survey-based study established that firefighting training programs among industrial workers in India are characterized by high frequency and positive perception, yet are functionally compromised by systemic deficiencies, particularly the absence of continuous reinforcement and industry-specific relevance. While the workforce is highly motivated and increasingly exposed to advanced technologies like VR, the failure to integrate audit findings and prioritize specialized training modules prevents these programs from translating perception into robust, measurable improvements in real-world preparedness.

The evidence demands a shift from fragmented, compliance-oriented drills toward a dynamic, integrated, and human-centric approach. The overwhelming support for a standardized national framework serves as a critical policy mandate to enforce consistency across high-risk sectors.

7.1 Recommendation and Further Study

Primary Recommendation: Implement a Standardized Integrated Fire Preparedness Performance Model (IFPPM) nationally, focusing specifically on:

1. **Mandatory Sector-Specific Modules:** Enforcing specialized training content tailored to the unique risks of high-hazard industries (e.g., chemical, oil and gas), moving beyond generic safety content.
2. **Continuous Learning Loop:** Mandating the systematic integration of all fire and electrical audit recommendations into refresher training modules to ensure lessons learned translate directly into improved practice and address specific workplace vulnerabilities.
3. **Strategic VR Integration:** Overcoming cultural barriers ("not considered necessary") and technical deficits (lack of staff) to strategically integrate immersive technologies, ensuring that VR is linked to performance-based outcomes and stress management protocols.

Further Study: Future research should focus on longitudinal studies to rigorously assess the long-term skill transferability and measurable performance impact of VR/AR technologies in specific industrial contexts. Additionally, qualitative research is needed to explore the behavioral and psychological dynamics of industrial workers during real-time emergencies, providing deeper context for the quantitative findings on confidence, stress management, and decision-making under duress.

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