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Examining the Impact of Specialized Firefighter Training on Improving Crisis Management Performance in Urban Incidents (Case Study: Karaj City, 2022–2024)

R. Khorshidi¹, R. Sarvar^{2,*}, M. Moghoufehi³

¹ M.A. Graduate in Crisis Management, Islamic Azad University, Science and Research Branch, Tehran, Iran

² Full Professor and Faculty Member, Islamic Azad University, Science and Research Branch, Tehran, Iran

³ M.A. Graduate in Crisis Management, Islamic Azad University, Science and Research Branch, Tehran, Iran

ARTICLE INFO	ABSTRACT
Article History: Received 11 March 2025 Received in revised form 28 May 2025 Accepted 3 June 2025 Available online 12 September 2025	Karaj, located at the southern foothills of the Alborz Mountains, is exposed to frequent natural hazards such as earthquakes and floods, which places high demands on the crisis management capabilities of its fire service. This study examined changes in the crisis management performance of firefighters in Karaj following specialized training programs delivered between 2022 and 2024. Using a pretest–posttest design, data were collected from 100 firefighters with a researcher-designed questionnaire whose validity was confirmed and whose reliability was acceptable (Cronbach's $\alpha = 0.87$). Performance was assessed in three dimensions: structural–organizational status, productivity and efficiency, and financial performance. Data were analyzed in SPSS with paired-samples <i>t</i> tests and analysis of covariance (ANCOVA), with pretest scores as the covariate. Mean scores increased significantly after training in all three dimensions ($p < 0.05$): structural–organizational status from 31.12 to 34.65, productivity and efficiency from 29.87 to 33.91, and financial performance from 31.05 to 34.98. These findings suggest that specialized training is associated with improved crisis management performance in the fire service and may contribute to urban resilience. Because the study lacked a control group and relied on self-reported measures, future research should use controlled designs and objective indicators of operational performance, such as response times and incident outcomes.
Keywords: Specialized Training; Crisis Management; Organizational Performance; Firefighters; Karaj	

1. INTRODUCTION

In the contemporary world, cities as densely populated and complex centers are increasingly confronted with a growing range of incidents and crises. Urban emergencies such as fires, floods, earthquakes, and industrial accidents not only result in substantial financial losses but also pose serious threats to human life. According to United Nations reports, more than 50 percent of the world's population currently resides in urban areas, and this figure is projected to reach 68 percent by 2050, thereby underscoring the critical importance of effective crisis management.

* Corresponding Author: R.sarvar@gmail.com
Islamic Azad University, Science and Research Branch, Tehran, Iran



Firefighters, as frontline responders in emergencies, play a pivotal role in mitigating the impacts of such incidents. However, their performance is influenced by multiple factors, including the level of specialized training, availability of equipment, organizational coordination, and psychological readiness.

Specialized training which encompasses technical, tactical, and psychological skills can facilitate rapid decision-making, reduce response time, and enhance overall safety. Focusing on the impact of specialized training on firefighters' performance in urban crisis management, the present study seeks to identify the strengths and weaknesses of current training systems. Furthermore, by examining both global and local experiences, the study proposes recommendations for improving training programs with the aim of strengthening crisis management systems in high-risk cities such as Tehran, New York, and Tokyo.

The importance of this topic becomes even more evident when international statistics indicate that insufficient training is one of the leading causes of failure in rescue operations, while investment in specialized training can increase survival rates by up to 30 percent. The ultimate goal of this study is to provide a practical framework for policymakers and fire service managers to enhance overall performance through the integration of modern technologies such as virtual simulations and artificial intelligence-based training systems.

2. LITERATURE REVIEW

Early research conducted in the 1990s emphasized the importance of foundational training in crisis management. For example, studies have shown that comprehensive training improves real-world performance in emergency situations by focusing on learning processes and the transfer of knowledge into practice [1]. These approaches, grounded in continuous learning models, conceptualize learning as an integral part of performance and emphasize the transfer of skills to real-life operational contexts. Team-based training in crisis management, using tactical decision-making games, has also been found to enhance coordination and improve performance under stressful conditions [2].

In the early 2000s, research attention shifted toward psychological dimensions and implicit coordination in firefighting training. Findings revealed that higher levels of experience and training contribute to stronger implicit coordination in firefighting operations, thereby influencing the design of training programs for emergency responders [3]. Moreover, training for decision-making under stress such as in the context of wildland fires has been shown to be essential for developing leadership skills and improving crisis-response performance [4]. Other studies have highlighted the influence of fatigue and training status on firefighter performance, demonstrating that resistance-based training can improve physical readiness and reduce injury risk [5].

In recent years (2010–2025), increasing attention has been given to specialized training and its impact on organizational performance. For instance, government-provided local training programs including leadership development and workplace infrastructure have been shown to improve firefighter performance [6]. Research on volunteer firefighting training within civil protection frameworks has provided practical assessments and recommendations, emphasizing the importance of structured training for crisis response [7]. Furthermore, the effects of training, leadership, and workplace environment on employee performance in fire services have been examined, showing positive impacts on operational efficiency [8].

During public health crises such as the COVID-19 pandemic, studies have proposed alternative training approaches for fire commanders, indicating that virtual training can help maintain physical and psychological conditions without negatively affecting learning outcomes [9]. The effects of training programs on the performance of fire service personnel have also been evaluated, with findings demonstrating improvements in task execution [10]. Additionally, research mapping leadership competencies in initial professional firefighter training programs has highlighted the significance of such skills for high-level performance [11].

The economic value of establishing firefighter training academies for urban crisis management has likewise been investigated, with results confirming their long-term economic benefits [12]. Multimodal training programs for first responders in medical emergencies have shown positive effects on preparedness and performance [13]. Factors influencing emergency response time such as firefighters' local knowledge have also been found to enhance performance outcomes [14].

Finally, training models such as oscillatory conditioning designed to improve hierarchical physical fitness have demonstrated their effectiveness in enhancing firefighters' job performance [15]. Critical reflective training for new firefighters has been identified as a method for strengthening crisis-management capabilities [16]. Crisis-management education incorporating tactical decision-making games has been shown to improve performance outcomes [17]. Other studies have examined behavioral responses such as alcohol use following exposure to traumatic events, demonstrating that such reactions are influenced by unit-level performance resources [18]. Research on learning from failures in emergency response has emphasized the need for continuous improvement in training processes [19], while team-based crisis-management training has been shown to address the challenges associated with distributed decision-making environments [20].

3. THEORETICAL FOUNDATIONS AND CONCEPTUAL FRAMEWORK

3.1. Concept of Training and Specialized Training

Training is defined as a purposeful process aimed at developing and transferring knowledge, skills, and attitudes. Specialized training in firefighting extends beyond general instruction and includes technical training, such as advanced fire suppression and the operation of high-pressure equipment, incident command system training, complex search-and-rescue instruction, and psychological crisis-management programs [21].

The effectiveness of training depends on several factors, including course design, instructional methods (theoretical and practical), repetition, field exercises, and post-training evaluation.

3.2. Learning Theory and Transfer of Learning to Performance

Organizational learning theories emphasize that learning can be translated into organizational performance through three key stages:

1. acquisition and consolidation of knowledge and skills;
2. transfer of acquired skills to the workplace; and
3. organizational reinforcement supporting the application of newly acquired behaviors.

Kirkpatrick's four-level model reaction, learning, behavior, and results provides a suitable framework for evaluating specialized training programs. In crisis-oriented environments, effective transfer of learning requires scenario-based simulations and practical field exercises to facilitate the application and retention of appropriate behaviors under stressful conditions.

3.3. Crisis Management and Organizational Performance

Crisis management is a process encompassing prevention, preparedness, response, and recovery [22]. Performance in crisis management can be reflected in indicators such as response time, decision-making accuracy, inter-organizational coordination, and optimal resource utilization.

According to the Balanced Scorecard model [23], financial performance represents only one component of a broader performance framework influenced by learning and growth, internal processes, and customer/community perspectives. This model provides a theoretical basis for explaining how training, as an aspect of learning and growth, may contribute to process improvement and, ultimately, improved organizational and financial performance.

3.4. Organizational Resilience and Adaptive Capacity

Adaptive capacity theory suggests that organizations characterized by adaptability, continuous learning, and flexible structures may demonstrate greater capacity to respond effectively to shocks and disruptions [24].

Specialized training may contribute to adaptive capacity by strengthening professional skills, providing simulated crisis experience, and fostering a culture of accountability and responsiveness.

3.5. Conceptual Framework

Based on the theoretical foundations discussed above, the conceptual framework of the study is structured around the following variables:

Independent Variable: Specialized firefighter training, including technical, managerial, and psychological dimensions.

Mediating Variables: Decision-making capability, team coordination, and organizational adaptability.

Dependent Variable: Crisis-management performance, reflected in structural and organizational status, productivity and efficiency, and financial performance.

The proposed framework assumes that specialized training contributes to improved crisis-management performance by strengthening individual competencies and organizational mechanisms that facilitate effective operational responses.

Conceptual Factors/Mechanisms: Decision-making capability, team coordination, and organizational adaptability.

3.6. Conceptual Model

Based on the theoretical foundations and proposed relationships among the study variables, the conceptual model of the research is presented in Diagram 1.

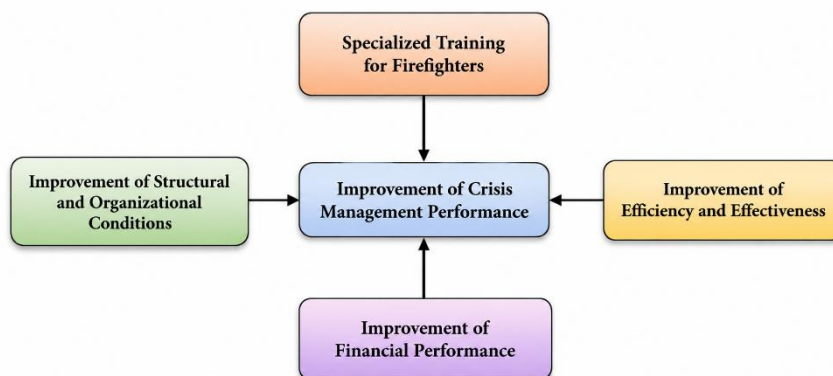


Diagram. 1. Conceptual model of the factors contributing to improved crisis management performance

4. METHODOLOGY

4.1. Research Design

This study employed an applied research approach and used a pre-test/post-test design to examine changes in the selected performance dimensions following specialized firefighter training. Descriptive and inferential statistical methods were used to analyze the collected data.

4.2. Statistical Population and Sample

The statistical population consisted of firefighters employed by the Fire Department of Karaj City during the study period (2022–2024). A total of 100 firefighters participated in the study and were included in the final statistical analysis.

4.3. Sampling Method

Participants were selected from the statistical population using a simple random sampling method.

4.4. Data Collection Instrument

Data were collected using a researcher-developed questionnaire consisting of 30 items covering three performance dimensions:

1. structural and organizational status;
2. productivity and efficiency; and
3. financial performance.

The questionnaire was developed based on a review of the relevant literature and a local needs assessment. The reliability of the instrument was assessed using Cronbach's alpha, which yielded an overall coefficient of 0.87, indicating good internal consistency. The content and face validity of the questionnaire were evaluated and confirmed by academic supervisors and subject-matter experts.

4.5. Implementation Procedure

The study involved the implementation of specialized training courses followed by an assessment of changes in the selected performance dimensions using pre-test and post-test measurements. Performance indicators were assessed before and after the training intervention to determine whether statistically significant changes occurred following the training.

4.6. Data Analysis

Data were analyzed using SPSS software. Descriptive statistics, including means and standard deviations, were used to summarize the data. The normality of the study variables was assessed using the Kolmogorov–Smirnov and/or Shapiro–Wilk tests, as appropriate.

Paired-samples t-tests were used to compare pre-training and post-training scores. Where applicable to the subsequent analyses, Levene's test was used to assess the homogeneity of variance assumption. Analysis of covariance (ANCOVA) was also conducted to examine training-related differences while statistically controlling for pre-test scores and other variables included in the original analytical model. Statistical significance was evaluated at the $p < 0.05$ level.

5. DATA ANALYSIS AND FINDINGS

5.1. Demographic Characteristics of Respondents

The questionnaire developed based on the theoretical framework was distributed among firefighters across the selected study locations. Ultimately, a total of 100 fully completed questionnaires were obtained and included in the statistical analysis.

Regarding professional work experience, 47% of the respondents had less than five years of firefighting experience, 30% had between five and ten years, 20% had between ten and fifteen years, and 3% had more than fifteen years of professional experience.

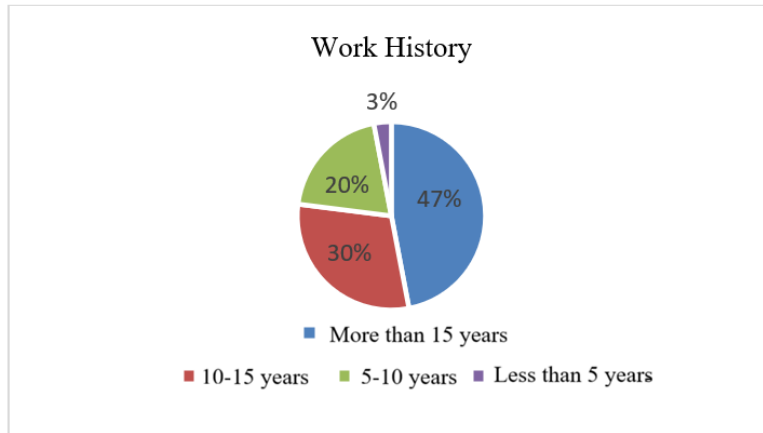


Fig. 1. Frequency Percentage of Respondents by Work Experience

The age distribution of the respondents is presented in Figure 2. The largest proportion of respondents belonged to the 35–40-year age group, whereas the smallest proportion was observed among respondents older than 40 years.

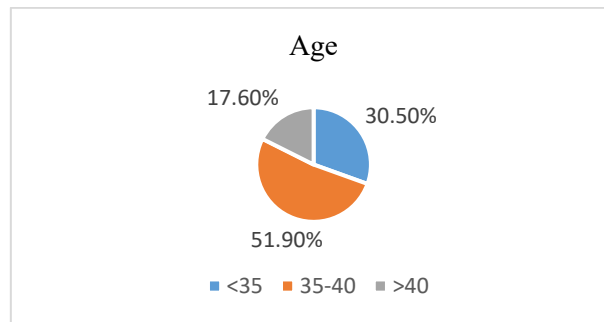


Fig. 2. Frequency Percentage of Respondents by Age

The educational characteristics of the respondents are presented in Figure 3. The largest proportion of respondents held a bachelor's degree (31.9%), whereas the smallest proportion (12.1%) had an educational qualification higher than a bachelor's degree.

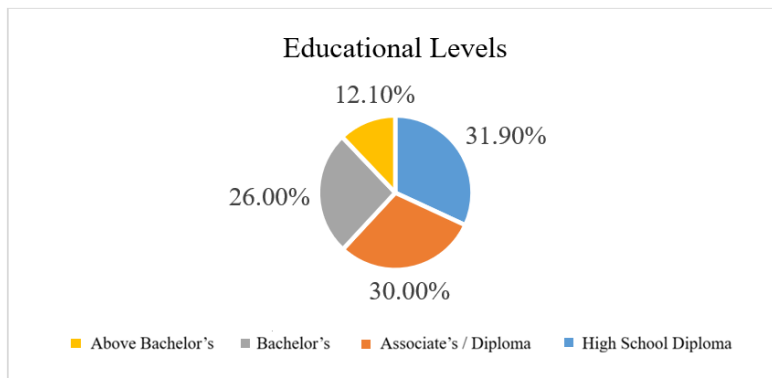


Fig. 3. Frequency percentage of respondents by level of education

As shown in Figure 4, the majority of respondents were married (82.60%).

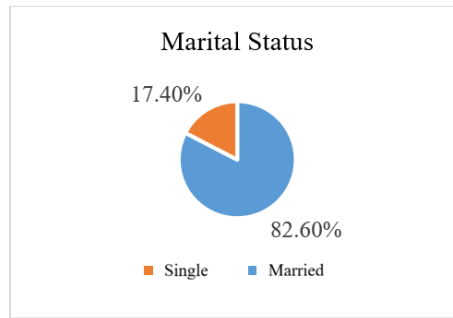


Fig. 4. Frequency Percentage of Respondents by Marital Status

A summary of the main demographic characteristics of the respondents is presented in Table 1.

Table 1. Summary of Respondents' Demographic Characteristics

Variable	Category	Frequency	Percentage
Gender	Male	100	100%
Age (years)	Mean (SD)	36.2 (± 7.8)	
Work Experience (years)	Mean (SD)	10.1 (± 6.2)	
Education	Diploma / Associate / Bachelor / Higher	(Distribution reported in thesis)	

5.2. Reliability and Normality Assessment

The reliability of the research instrument was assessed using Cronbach's alpha. The overall Cronbach's alpha coefficient was 0.87, indicating good internal consistency of the questionnaire.

The normality of the data was evaluated using the Kolmogorov–Smirnov and/or Shapiro–Wilk tests. The results indicated that the distributions of most of the study variables did not significantly deviate from normality ($p > 0.05$). Accordingly, the use of the selected parametric statistical procedures was considered appropriate for variables satisfying the relevant assumptions.

Important reporting note: The exact normality test used for each variable, together with its test statistic and p-value, should be reported if these values are available in the original statistical output.

5.3. Descriptive Statistics of Pre- and Post-Training Scores

Before conducting inferential analyses, the mean and standard deviation of each performance dimension were examined for the pre-test and post-test measurements. As shown in Table 2, the mean post-training scores were higher than the corresponding pre-training scores across all three performance dimensions.

Table 2. Descriptive Statistics for Pre- and Post-Training Scores

Indicator	Pre-Test Mean $\pm$ SD	Post-Test Mean $\pm$ SD
Structural and Organizational Status	31.12 $\pm$ 0.85	34.65 $\pm$ 0.85
Productivity and Efficiency	29.87 $\pm$ 0.78	33.91 $\pm$ 0.78
Financial Performance	31.05 $\pm$ 0.94	34.98 $\pm$ 0.47

The largest absolute increase in mean score was observed for Productivity and Efficiency, which increased from 29.87 before training to 33.91 after training. Structural and Organizational Status increased from 31.12 to 34.65, while Financial Performance increased from 31.05 to 34.98.

5.4. Comparison of Pre- and Post-Training Scores

A paired-samples t-test was used to determine whether the differences between pre-training and post-training scores were statistically significant. The results are presented in Table 3.

Table 3. Comparison of Pre- and Post-Training Scores Using the Paired-Samples t-Test

Indicator	Pre-Test Mean	Post-Test Mean	t	df	p
Structural and Organizational Status	31.12	34.65	2.91	99	0.015
Productivity and Efficiency	29.87	33.91	3.27	99	0.006
Financial Performance	31.05	34.98	2.88	99	0.018

The results indicate that post-training scores were statistically significantly higher than pre-training scores across all three dimensions ($p < 0.05$). The mean score for Structural and Organizational Status increased from 31.12 to 34.65 ($t = 2.91, p = 0.015$), Productivity and Efficiency increased from 29.87 to 33.91 ($t = 3.27, p = 0.006$), and Financial Performance increased from 31.05 to 34.98 ($t = 2.88, p = 0.018$). Among the three dimensions, Productivity and Efficiency showed the largest absolute increase in mean score ($\Delta M = 4.04$). However, the magnitude of the training effect should not be inferred solely from the t statistic or the mean difference. A standardized effect-size measure, such as Cohen's d , would be required to determine and compare the magnitude of the effects.

5.5. Homogeneity of Variance Assessment

Levene's test was used to assess the homogeneity of variance assumption where applicable to the subsequent between-group/ANCOVA analysis. The results are presented in Table 4.

Table 4. Levene's Test Results

Variable	F	p	Interpretation
Structural and Organizational Status	1.24	0.268	Homogeneity assumption satisfied
Productivity and Efficiency	0.95	0.333	Homogeneity assumption satisfied
Financial Performance	1.73	0.190	Homogeneity assumption satisfied

For all three variables, Levene's test was non-significant ($p > 0.05$), indicating no evidence of violation of the homogeneity of variance assumption for the analyses to which this assumption applies.

It should be noted that homogeneity of variance is not an assumption of the paired-samples t-test itself. Therefore, the results of Levene's test are relevant to analyses involving comparisons across independent groups or to the corresponding assumptions of the subsequent ANCOVA, rather than to the paired-samples t-test.

5.6. Analysis of Covariance (ANCOVA)

Analysis of covariance (ANCOVA) was used to examine the effect of training on the performance dimensions while statistically controlling for pre-test scores and the confounding variables included in the original analytical model. The results are presented in Table 5.

Table 5. ANCOVA Results for the Effect of Training on Performance Dimensions

Indicator	F	p	Statistical Result
Structural and Organizational Status	6.12	0.015	Significant
Productivity and Efficiency	8.34	0.006	Significant
Financial Performance	5.91	0.018	Significant

The ANCOVA results indicate statistically significant training-related differences for all three performance dimensions after controlling for the variables included in the analysis ($p < 0.05$). Structural and Organizational Status showed a statistically significant result ($F = 6.12, p = 0.015$), as did Productivity and Efficiency ($F = 8.34, p = 0.006$) and Financial Performance ($F = 5.91, p = 0.018$).

The highest F statistic was observed for Productivity and Efficiency ($F = 8.34$). However, the higher F statistic should not, by itself, be interpreted as evidence that this dimension had the strongest effect. Comparison of effect magnitude requires an appropriate effect-size measure, such as partial eta squared (partial η^2).

5.7. Summary of Statistical Findings

The statistical analyses consistently indicated higher post-training scores across the three examined performance dimensions. The paired-samples t-test showed statistically significant pre- to post-training differences in Structural and Organizational Status, Productivity and Efficiency, and Financial Performance. The relevant homogeneity-of-variance tests were non-significant, and the reported ANCOVA results also indicated statistically significant training-related differences after adjustment for the variables included in the original model.

The principal statistical findings are summarized in Table 6.

Table 6. Summary of Statistical Analysis Results

Statistical Analysis	Significance	Overall Result
Reliability Analysis	Cronbach's $\alpha = 0.87$	Good internal consistency
Normality Assessment	$p > 0.05$ for most variables	No significant departure from normality for most variables
Paired-Samples t-Test	$p < 0.05$ for all three dimensions	Post-training scores were significantly higher
Levene's Test	$p > 0.05$	No evidence of violation of homogeneity of variance
ANCOVA	$p < 0.05$ for all three dimensions	Significant training-related differences after statistical adjustment

Overall, the findings provide evidence of statistically significant improvements in Structural and Organizational Status, Productivity and Efficiency, and Financial Performance following the training intervention. Nevertheless, statistical significance should be distinguished from the magnitude of the effect. Therefore, effect-size measures should be reported, where available, to determine the practical magnitude of the observed changes.

6. DISCUSSION

The findings of this study indicate that specialized training for firefighters has a significant and positive impact on the performance of urban crisis management. These results are consistent with previous research in the fields of training and crisis management, such as Haddow et al. (2017) and Alexander (2013) [22,25]. Specialized training enhances tactical knowledge, strengthens decision-making skills under pressure, and improves inter-unit coordination, thereby increasing operational capacity and reducing human errors.

Among the various performance dimensions, efficiency and productivity demonstrated the highest sensitivity to training ($F = 8.34, p = 0.006$). This finding aligns with the Balanced Scorecard framework, which emphasizes that human capital development and learning lead to improvements in internal processes and organizational productivity [23]. Additionally, training contributed to improving the structural and organizational status of the fire department, enhancing cohesion and coordination among units, which is consistent with the principles of centralized command and the Incident Command System (ICS).

Notably, even financial performance showed improvement following the training ($F = 5.91, p = 0.018$), although the effect size was smaller. This improvement can be attributed to reduced errors, more efficient use of equipment,

and decreased repetition of tasks. From a local perspective, the findings provide evidence supporting investment in specialized training, particularly in high-risk cities such as Karaj.

Nevertheless, several limitations should be considered. These include the relatively small sample size, the short observation period, and incomplete control over certain environmental and organizational factors. Therefore, the generalization of the results should be approached with caution, and future research could benefit from longitudinal or multilevel models to examine long-term effects.

7. CONCLUSION

The study shows that specialized firefighter training was associated with improvements in urban crisis management performance in three key areas:

Improvement of organizational structure and systems: Specialized training enhanced unit cohesion, clarified roles, and strengthened command flow.

Increase in operational efficiency and productivity: After training, personnel were able to perform operations with greater speed, accuracy, and coordination.

Enhancement of financial performance and resource utilization: Training led to reduced errors, more efficient use of resources, and optimized equipment utilization.

Overall, this research emphasizes that crisis management institutions, particularly fire departments, should integrate specialized training as a permanent component of human resource development. Continuous training, regular evaluation of effectiveness, and updating educational content according to global standards can increase urban resilience and reduce both human and financial losses during crises.

Overall, the findings show significant improvements in crisis management performance after specialized training, supporting the primary hypothesis as well as all secondary hypotheses of the study.

Authors' Contributions

All authors contributed to the conception and design of the study, the interpretation of the results and the preparation of the manuscript. All authors read and approved the final manuscript.

Declaration of Generative AI Use

During the preparation of this work, the authors used ChatGPT (OpenAI) to improve the language and readability of the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Ethics Considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Participation was voluntary, all firefighters were informed of the aims of the study and gave informed consent, and they were free to withdraw at any time without any consequences for their employment. The questionnaires were coded rather than named so that pretest and posttest responses could be matched, the confidentiality of the data was maintained, and the results were reported only in aggregate form. As this was a non-interventional survey of professionals, formal approval from an ethics committee was not obtained.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to ethical and confidentiality considerations.

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