

# Fire Risk Assessment and Educational Intervention in Operating Room Personnel: An Intervention Study in Isfahan Hospitals

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## Abstract

**Aim:** The purpose of this investigation was to evaluate the impact of educational intervention on operating room personnel's knowledge of fire factors and lowering the level of fire risk in some selected hospitals in Isfahan city. **Materials and Methods:** This interventional study was conducted on 113 operating room personnel of Isfahan hospitals in Iran. A standard questionnaire (with 28 questions) was employed to assess the level of knowledge of the operating room personnel about the sources of combustion and ways to prevent it. The fire risk assessment method for engineering was employed to assess the fire risk of hospitals, and the risk level was calculated for the building and its contents (R), personnel (R1), and activity risk (R2). SPSS version 24 was used to analyze the data. **Results:** Forty-eight participants (36.1%) were men, and 85 participants (63.9%) were women. The findings demonstrated that the mean (standard deviation) score of personnel's fire safety knowledge was statistically enhanced before and after the educational intervention (10.62 [3.20] and 15.40 [2.66], respectively ( $P < 0.01$ )). The findings of the fire risk assessment demonstrated that the risk of personnel has the maximum risk score, which is higher than one in all instances. Following personnel risk, the building and its contents risk had the maximum overall risk score. Following the educational intervention, the findings of the fire risk assessment demonstrated that the overall risk of the building and its contents, the overall risk of personnel, and the overall risk of the activity all reduced from 0.588–0.423, 4.174–3.408, to 0.543–0.498, respectively. **Conclusion:** Proper implementation of educational programs can reduce fire risk while also enhancing personnel knowledge and improving operating room safety. Accordingly, hospitals should incorporate the implementation of educational programs into their routine activities.

**Keywords:** Accident prevention, educational early intervention, operating rooms, risk assessment

## INTRODUCTION

As one of the most significant institutions offering health and treatment services, hospitals play a critical role in helping diseased individuals regain their physical and mental health. They also play a crucial role in the education of health and treatment experts, which helps to improve society's overall health. Therefore, it becomes more evident how crucial it is to ensure the health of the personnel in these units. To provide quality care, healthcare providers require a safe environment.<sup>[1-3]</sup> According to the American Society of Safety Engineers (ASSE), hospital personnel is 41% more likely than employees of other fields to miss work time as a result of work-related diseases and damages. This association reported in October 2013 that 2 million workdays were lost and 1.13 billion dollars in damages

were caused by workplace damages involving healthcare personnel.<sup>[4]</sup>

A potential risk to service facilities like hospitals, fire is one of the most significant physical factors affecting the workplace. It is also one of the most dangerous phenomena that result in significant financial and human losses.<sup>[5-9]</sup> Hospitals are among the high-risk environments for fire because of the

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unique circumstances surrounding their gathering of people, the existence of disabled and diseased people, chemicals, and flammable compounds. The occurrence of fire in hospitals is possible if the safety principles are disregarded, resulting in irreparable expenses.<sup>[10]</sup> Such hospital incidents include the situation in which a fire killed 89 people (85 patients and 4 staff members) in the Calcutta Hospital in India.<sup>[11]</sup> Over 8000 hospital fires occur on average annually worldwide, according to data released by the American National Fire Protection Association in 2005. Disastrous outcomes could result from improper management in this field.<sup>[12]</sup>

The operating room is one of the units in which there is consistently a very high risk of adventures among the different hospital departments. The operating room is regarded as one of the hospital's most crucial and sensitive units; in fact, it serves as both the hospital's main source of power and its most significant output, containing a number of pricey and sophisticated pieces of equipment. In other words, the operating room is the center of accumulation of all types of technological, scientific, physical, and behavioral assets of hospital units, and notwithstanding the different activities and specialties, adventures like fire, one of the operating room's most significant potential risks, endanger its very existence.<sup>[13]</sup> For the anesthesia and surgery personnel, who are more subjected to the risks of its occurrence, fire is regarded as a potential risk in modern surgery.<sup>[14]</sup> The Pennsylvania Patient Safety Organization's analysis was published by the Emergency Care Research Institute (2015), which approximated that 550–650 operating room fires take place each year in the United States.<sup>[15]</sup> The operating room has a higher, more serious, and more catastrophic fire risk than other units of the hospital because it contains all three of the fire triangle's components, which are needed to initiate a fire, including fuel, an ignition source, and oxidizers.<sup>[16,17]</sup>

The surgery group (surgery personnel, anesthetists, and nurses) must be well-versed in the sources of ignition, combustible materials, and oxidants present in their working environment to prevent the occurrence of fire. A potentially disastrous fire may occur if they do not pay close attention to the connection between the three arms of the "fire triangle" and how it is developed. In fact, these teams can significantly lower the risk of fire in the operating room if they carry out their tasks properly and follow safety precautions when using the equipment.<sup>[16]</sup> Numerous adventures have taken place as a result of nonobservance of safety principles during surgery and inadequate education and knowledge of operating room personnel concerning fire prevention and control methods; the majority of these adventures were caused by personnel's lack of knowledge of risk factors in the workplace. Therefore, increasing staff knowledge of risks and safety training is one of the most effective ways to prevent fire in operating rooms.<sup>[18]</sup>

Safety training is a process through which personnel gains knowledge, acquire new skills, and are inspired to perform tasks in a particular manner. According to investigations,

safety training is critical in decreasing adventures and enhancing safety culture in organizations.<sup>[19]</sup> Furthermore, risk assessment is an essential and inevitable process to guarantee the safety of the conditions.<sup>[20]</sup> Fire risk assessment is a systematic process to recognize and assess fire risks (based on the probability of occurrence and potential outcomes) and to determine operational preferences to prevent fire occurrence and deal with fire-related adventures.<sup>[8]</sup> Several tools have been provided to check the fire risk in hospitals. The fire risk assessment method for engineering (FRAME) method is one of the most common methods used in fire risk assessment. Hakamabadi *et al.*, in a hospital complex, investigated the fire risk assessment of different departments using the FRAME method and reported that the risk of employees in the operating room was at an unacceptable level and needed interventions to reduce it.<sup>[21]</sup> Jahangiri *et al.* also conducted and reported fire risk assessment in some selected hospitals in Shiraz. In their study, the fire risk in most hospitals was at an unacceptable level.<sup>[7]</sup> These researchers stated that the FRAME method is a suitable method for investigating hospital fire risk.

Given the importance of considering fire safety in operating rooms, it is essential to employ the fire risk assessment process to pinpoint the operating rooms' weak points and develop an educational intervention strategy to increase staff knowledge. To decrease the level of fire risk in a few selected hospitals in Isfahan City, this study was conducted with the following objectives: determining the level of fire risk in operating rooms using the FRAME method, investigating the effect of educational intervention on the level of fire safety knowledge of operating room personnel, and investigating the effect of educational intervention on the level of fire risk.

## MATERIALS AND METHODS

### Participants

This current interventional study involved 133 participants working in the operating rooms of 11 hospitals in the city of Isfahan. The average (standard deviation) knowledge of operating room personnel regarding fire prevention was reported as 60.19 (17.74) in similar studies.<sup>[14]</sup> Considering the confidence level of 95% and the error of 3 points, the sample size was calculated using Equation 1:

$$n = \frac{z^2 \delta^2}{d^2} = \frac{1.96^2 \times 17.74^2}{3^2} \approx 133 \quad (1)$$

The participants were chosen from among operating room personnel at selected hospitals. The samples were chosen using a stratified sampling method, and the required number of samples was chosen based on the number of participants working in each hospital's operating rooms. The current research was approved by the Ethics Committee of Isfahan University of Medical Sciences. All participants were over 18 years of age, and the informed consent form for participating in the research was read and signed. The current research was carried out in three phases as follows:

### First phase: A preliminary evaluation of the workplace Determining the personnels' occupational and demographic characteristics

A researcher-designed checklist was prepared to ascertain the demographic and occupational characteristics of the participants under investigation. Data was gathered regarding occupation, age, gender, work experience, type of hospital, education level, and marital status.

#### Determining personnel fire knowledge

A standard questionnaire presented in the research by Tola *et al.* was employed to assess operating room personnels' knowledge of sources of combustion and methods for preventing it in the operating room.<sup>[17]</sup> The questionnaire contained 28 questions divided into two sections and was designed to assess personnel's knowledge of fire sources in operating rooms and fire prevention techniques in these settings. The first section included 19 questions that tested the personnel's knowledge and gave each participant a score on a quantitative scale. Each question had a score based on its significance and type, and if the response was correct, the question's score was considered; if the response was incorrect, the question's score was not considered. The total of the scores from each question is used to determine the final score. If participants appropriately respond to all of the questions, they receive the highest possible score for the questionnaire; however, for each incorrect response, the score for that question was deducted from the final score. This section of the questionnaire had a maximum score of 26. The frequency of responses was determined by the qualitative scoring of the nine questions in the second section of the questionnaire. The second section of this questionnaire in the current study was divided into two sections of five and four questions based on the goals of the current study and the evaluation of some of the questions in the questionnaire before and after the educational intervention. Participants completed the first five questions only before the educational intervention, while before and after the educational intervention, the subsequent four questions were completed and analyzed. The reliability and validity of the Persian version of this questionnaire were investigated by the research team of the current study because it was employed in this study. The intraclass correlation coefficient (ICC) was used to assess the reliability of this questionnaire. In addition, the Lawshe formula and the content validity ratio (CVR) index were employed to determine the content validity of the Persian version of the questionnaire, and this index was specified after analysis by 15 specialists involved in the field of fire safety. The reliability and validity findings of the Persian version of the questionnaire demonstrated that the ICC value was 0.87 and the CVR value was 0.846, indicating that the Persian version of the questionnaire has high reliability and validity.<sup>[22]</sup>

#### Fire risk assessment

The FRAME was employed for this purpose.<sup>[23]</sup> FRAME is a risk assessment approach that calculates fire risk independently for three different aspects. These three aspects are the risk to the

building and its contents (R), the risk to the personnel (R1), and the risk to the building's activities (R2). Different correlations and formulas are employed in this method to assess fire risk, and the risk level for all three mentioned aspects is determined independently and through the general relationship below by conducting complex and long calculations. Fire risk is described in this relationship as the quotient of the potential risk on the acceptance and protection level (Equation 2).

$$R = \frac{P}{A \times D} \quad (2)$$

Where P represents the potential risk, A represents the level of risk acceptance, and D represents the protection level. Other quantities and parameters must be calculated and extracted to calculate each of these three parameters. The calculation result, i.e., fire risk (R), is acquired as a unitless number using this method. Given that safety is a relative concept, this number will constantly be greater than zero. Decisions about the current risk can be made in one of two ways:<sup>[23]</sup>

According to the relationship above, in the first scenario, if  $R \leq 1$ , the numerator is smaller than or equal to the denominator, meaning that the protective interventions and risk acceptance level are equal to or greater than the established potential risk, and the risk level can be accepted. In other words, the fire safety of the evaluated environment is satisfactory. It should be clear that the conditions will be better and more favorable if the more this number tends toward zero. In the second scenario, if  $R > 1$ , it demonstrates that the potential risk in the current state is greater than the multiplication of the protection level by the acceptance level, and the safety measures in place are insufficient. The risk acquired in this state is unacceptable. In other words, the space under study does not meet optimal safety standards. Clearly, the fire safety situation deteriorates as the risk number increases above one.<sup>[23]</sup>

#### Second phase: Educational intervention implementation

Using stratified sampling with proportional allocation, 133 individuals from each of the hospitals under consideration were chosen as the intervention group for training. The participants individually participated in the training course designed regarding the fire safety issue in operating rooms in each hospital in two 2-h sessions (a total of 22 2-h sessions for the designated personnel of the operating rooms of 11 hospitals) after passing the administrative processes, obtaining approval from the head of the selected hospitals, and setting the date of the sessions. The research units completed the pre-test questionnaire at the initiation of the first session. The training program was then executed for the selected personnel. The issues were presented in the form of lectures, film screenings, and educational brochures during this training course. The educational content presented was as follows: 1. the significance of fire safety; 2. learning about the fire triangle; 3. educating personnel on scenarios that could result in a fire in operating rooms; 4. methods for fire prevention and management in operating rooms; 5. educating personnel about fire sources in operating rooms; and 6. extinguishing

the fire using carbon dioxide capsules in a practical manner and under the surveillance of the researcher, as well as the appropriate response in the event of a fire. It is worth noting that the personnel training was conducted by the researcher during the personnel's off hours to avoid interfering with patient care. In addition, the occupational health expert from each hospital and the head of the hospital worked together to coordinate the practical training section, which was carried out on the hospital grounds in strict accordance with safety principles.

### Third phase: Efficiency assessment of educational interventions

The personnel were once more asked to complete the fire safety knowledge questionnaire at this stage, following the completion of the fire risk assessment and the implementation of the fire safety training workshop. A fire risk assessment was also performed in the operating rooms of the researched hospitals, and the fire risk score was determined after the execution of the educational interventions, taking into account the personnel training and enhancing their level of knowledge compared to before the interventions' execution.

### Statistical analysis

SPSS software version 24 was employed to analyze the data. Descriptive statistics such as mean, standard deviation, minimum, and maximum were used to describe descriptive objectives. The *t*-test and paired *t*-test were employed to compare quantitative data in two independent and dependent groups. McNemar's non-parametric test was employed to compare the frequency of nominal qualitative variables before and after the intervention. For all tests, a significance level of  $\alpha = 0.05$  was taken into account.

## RESULTS

Table 1 displays the descriptive findings of the evaluated personnels' demographic and occupational characteristics. 48 personnel (36.1%) were men, and 85 personnel (63.9%) were women. There were 42 single individuals (31.6%) and 91 married individuals (68.4%). The individuals' work history was determined to have an average (standard deviation) of 9.38 (7.38). The participants in the research were 34.21 (8.42) years old on average (standard deviation). 13 (9.8%), 105 (78.9%), and 15 (11.3%) of those taking part in the research had an associate's degree, bachelor's degree, and specialized training in various clinical fields, respectively.

Table 2 shows the comparative results of personnels' knowledge of fire safety before and after training. The findings indicated that there was a statistically significant difference between the mean (standard deviation) scores of personnels' fire safety knowledge before and after the educational intervention (10.62 (3.20) and 15.40 (2.66), respectively ( $P < 0.001$ ).

Table 3 shows the findings of the ultimate risk of fire by separating the risk of the building and contents, the risk of personnel, and the risk of activity in two periods before and

**Table 1: Descriptive results of the demographic and occupational characteristics of the personnel studied**

Variables	Statistics	Value
Age (years)	Mean±SD	34.21±8.42
	Range	22–60
Work background (years)	Mean±SD	9.38±7.38
	Range	1–30
BMI	Mean±SD	24.95±3.44
	Range	19.5–28
Gender, <i>n</i> (%)	Man	48 (36.1)
	Female	85 (63.9)
Marital status, <i>n</i> (%)	Single	42 (31.6)
	Married	91 (68.4)
Education level, <i>n</i> (%)	Associate degree	13 (9.8)
	Bachelor	105 (78.9)
	Expert	15 (11.3)

SD: Standard deviation

**Table 2: Comparative results of personnel's fire safety knowledge scores before and after training**

Grouping	Average	SD	Minimum	Maximum	<i>P</i> *
Before training	10.6212	3.20	3.20432	0.27890	<0.001
After training	15.4091	2.66	2.66144	0.23165	

\*Paired sample *t*-test with a CL of 95%. SD: Standard deviation, CL: Confidence level

after the training intervention in the hospitals studied. The findings demonstrate that the maximum risk score in the hospitals under investigation is associated with individual risk, and in all instances, the risk score is  $>1$ . In other words, there is an unsatisfactory level of risk for individuals in all hospitals. In addition, the overall risk score for participants has the maximum score and is higher than the acceptable limit (risk score 1). After the risk to participants, the risk to buildings and contents has the maximum total risk score, while the risk to activities has the minimum total risk score. The sum of the building, content, and activity risks was  $<1$ , which was a satisfactory level. Only two Alzahra and Amin hospitals showed a risk  $>1$  and were unacceptable in terms of the building and its contents. Only Feiz Hospital among the evaluated hospitals had an unacceptable activity risk and was  $>1$ . The findings of the fire risk assessment following the educational intervention also demonstrated that implementing these interventions to enhance hospital staff members' knowledge can lower the risk score in all three aspects. The total risk of the building and its contents, the total risk to personnel, and the total risk of the activity decreased from 0.588–0.423, 4.174–3.408, to 0.543–0.498, respectively, after the implementation of educational interventions.

Table 4 shows the findings from an examination of the level of knowledge of participants with various levels of education before and after the educational intervention. The findings demonstrated a statistically significant difference in the personnel's fire safety knowledge scores across all education

groups before and after the training, with the knowledge score rising compared to the baseline ( $P < 0.05$ ). Furthermore, the findings of this section revealed that the knowledge score of specialists increased more than experts and associates as a consequence of the educational intervention. In addition, experts' knowledge scores have enhanced more than those of associates. In other words, individuals with a higher level of education benefited more from the training intervention than individuals with a lower level of education.

Table 5 shows the findings of the investigation into the initial section of the qualitative items of the fire safety knowledge

questionnaire. There was a statistically significant ( $P = 0.03$ ) increase in the knowledge score of the groups that agreed that fire safety training was essential during surgery compared to the group that did not agree with this statement. There was also a statistically significant ( $P = 0.03$ ) difference between the knowledge scores of those who reported having and those who did not report having the requisite knowledge and skills for fire prevention and management. The findings indicated that those who use fire prevention techniques in high-risk procedures like surgery scored higher on fire safety knowledge tests than those who did not use these techniques. However,

**Table 3: Fire risk of the investigated hospital's buildings, individuals, and activities before and after the intervention**

Hospital	Risk to building and contents		Risk to individuals		Risk to activity	
	Preintervention	Postintervention	Preintervention	Postintervention	Preintervention	Postintervention
Al-Zahra	1.503	1.356	5.309	4.790	0.795	0.718
Amin	1.403	0.041	5.302	0.620	0.775	0.040
Khorshid	0.083	0.075	1.890	1.706	0.132	0.119
Feiz	0.749	0.676	2.396	2.650	3.051	2.754
Shahid Beheshti	0.280	0.253	3.195	2.884	0.360	0.325
Omid	0.785	0.708	4.557	4.112	0.413	0.373
Imam Hossein	0.123	0.111	4.261	3.845	0.103	0.093
Imam Musa Kazim	0.607	0.580	3.522	3.400	0.319	0.300
Kashani	0.380	0.343	5.477	4.943	0.331	0.299
Chamran	0.436	0.393	7.470	6.740	0.461	0.416
Isabn-e-Maryam	0.029	0.026	1.990	1.804	0.052	0.047
Total	0.588	0.423	4.174	3.408	0.543	0.498

**Table 4: Findings from an examination of the level of knowledge of individuals with various levels of education before and after the educational intervention**

Education level	Intervention group	Average	Score reduction	SD	P*
Associate degree	Preintervention	10.7692	4.5	2.68901	<0.001
	Postintervention	15.2692		2.84650	
Bachelor	Preintervention	9.6923	5.8	3.17218	<0.001
	Postintervention	15.4615		2.65941	
Specialist (surgeon)	Preintervention	10.4000	5.9	3.85079	<0.001
	Postintervention	16.3333		2.49762	

\*Paired sample *t*-test with a CL of 95%. SD: Standard deviation, CL: Confidence level

**Table 5: Comparison of the mean score (standard deviation) of the fire safety knowledge in the questionnaire's qualitative items**

Qualitative items of the questionnaire	Grouping	Average	SD	P*
The necessity of fire safety training during surgery	Yes	10.98	3.20	0.03
	No	9.69	3.01	
Knowledge and skills required for fire prevention and management	Yes	11.18	3.08	0.027
	No	9.95	3.21	
Practicing fire prevention methods during surgery	Yes	10.65	3.21	0.839
	No	10.53	3.21	
The necessity of participating in fire extinguishing maneuvers in the operating room	Necessary	10.87	3.06	0.083
	Unnecessary	9.39	3.68	
Necessity of fire assessment during surgery	Yes	10.63	3.20	0.829
	No	10.42	3.25	

\*Student *t*-test with a CL of 95%. SD: Standard deviation, CL: Confidence level

this difference was not statistically significant ( $P = 0.839$ ). The participants who thought that performing fire extinguishing maneuvers was a requirement for their occupations scored better on fire safety knowledge than the other group. However, this difference was not statistically significant ( $P = 0.083$ ). Eventually, individuals who believed that fire assessment was essential during surgeries got a higher score of fire safety knowledge than others; however, this difference was not statistically significant ( $P = 0.829$ ).

Table 6 shows the findings of the investigation into the second section of the qualitative items of the fire safety knowledge questionnaire regarding the frequency of participants' responses to fire safety questions before and after the intervention. Following the implementation of the educational intervention, individual's fire safety knowledge was enhanced concerning all of the items covered in this section. However, there was only a statistically significant difference between the pre- and post-intervention results for the questions "knowledge of the location of fire warning and extinguishing equipment" and "knowledge of the reaction between oxygen and oil" ( $P < 0.05$ ).

## DISCUSSION

Because of the nature of the materials and equipment, continuing to work in operating rooms is risky. As a consequence, it is critical to focus on fire safety in hospital operating rooms, using the fire risk assessment process to recognize operating room weak points and developing an educational intervention strategy to enhance personnel knowledge. A specialized method of fire risk assessment was employed to evaluate the conditions of the operating rooms of selected hospitals in Isfahan City in this study, and an educational intervention was executed among the personnel present in these locations to enhance the level of knowledge of the personnel. A questionnaire was designed, and the status of participants was examined in the current research to determine the level of knowledge of operating room personnel in the field of fire safety. The findings demonstrated that the mean score for participants' knowledge of fire safety in operating rooms was minimal (10.62), and this score, when compared to the highest possible score on the questionnaire, showed that the condition among the personnel under investigation was worse than the mean level. These findings are consistent with the findings of other investigations that evaluated operating room personnel's

knowledge of fire safety in Iran. Abdollahi *et al.* investigated the knowledge of the operating room personnel of the Yazd University of Medical Sciences about combustion sources and prevention methods in their research. Their findings demonstrated that personnel knowledge of ignition sources was limited and that fire safety training programs should be held on a regular basis to enhance knowledge among operating room personnel.<sup>[14]</sup> In another investigation, Abdullahi *et al.*<sup>[14]</sup> discovered that operating room personnels' knowledge of ignition sources and fire preventative measures was low and that different training methods must be employed to enhance personnel knowledge. The findings of the research conducted by Davudian Talab *et al.*<sup>[24]</sup> are consistent with the findings of this study, and a significant proportion of operating room personnel in Shiraz hospitals have low or no knowledge. The findings of investigations carried out at the international level to ascertain the degree of knowledge of operating room staff members regarding fire safety are sometimes in agreement and sometimes not in agreement with the findings of the current study. According to Aygin *et al.*,<sup>[25]</sup> the knowledge level of fire hazards among operating room staff in Turkey is average. In another investigation, Andsoy *et al.*,<sup>[26]</sup> found that while operating room personnels' level of knowledge was appropriate, there was inadequate knowledge among personnel about the actions needed in the event of a fire. According to Sarp and İşlek,<sup>[27]</sup> research in Turkey, personnel have a high level of knowledge regarding how to deal with fires but not enough about how to prevent them. As a result, although Turkish hospitals are superior to those in Iran, they still have issues in some areas and must strategize and carry out the required interventions to increase personnel knowledge. The findings of this section of the research demonstrate that the country's operating room personnel have a minimal level of knowledge about fire safety, which can be attributed to the low level of safety in the country's hospitals, particularly operating rooms, and a shortage of adequate attention to related safety issues. Earlier studies, in particular, have reported on the safety level of Isfahan hospitals.<sup>[28]</sup> The accreditation process for hospitals, which includes monitoring and consideration of the safety situation, pays minimal attention to hospital safety issues and instead concentrates on crisis management. This is one of the reasons for the minimal level of safety in these hospitals.

The FRAME method was employed in this research to assess the fire safety risk posed by operating rooms in specified

**Table 6: Comparison of the frequency of responses to the second section of the qualitative items on fire safety knowledge before and after the intervention**

Question	Preintervention		Postintervention		$\chi^2$	P*
	Yes, n (%)	No, n (%)	Yes, n (%)	No, n (%)		
Knowing the location of the warning bell and its activity	56 (42.1)	77 (57.9)	68 (51.1)	65 (48.9)	1.95	0.162
Knowledge of urgent response evacuation plan	50 (37.6)	83 (62.4)	57 (42.9)	76 (57.1)	0.655	0.418
Knowledge of the location of fire alarms and extinguishing equipment	66 (49.6)	67 (50.4)	83 (62.4)	50 (37.6)	4.193	0.041
Knowledge of the reaction between oxygen and oil	77 (57.9)	56 (42.1)	123 (92.5)	10 (7.5)	32.661	<0.001

\*McNemar's nonparametric test with a CL of 95%. CL: Confidence level

hospitals. The final fire risk in all hospitals was calculated using the following parameters: Building and content risk, personnel risk, and activity risk. This section's findings demonstrated that the maximum score was attributed to individual's risk, and this parameter was at an unsatisfactory level. Except for the two hospitals, the risk of the building and its contents, the risk of activity, and the total risk level were reasonable for the other hospitals. These findings show that the risk to personnel is unfavorable, necessitating special attention to be paid to this area in hospital operating rooms. Furthermore, one of the justifications for the high risk of staff members is a lack of knowledge in the field of fire sources and methods of fire prevention and control. These findings are consistent with those of other investigations conducted in the country. In their investigation of the fire risk assessments of various units in a hospital complex, Hokmabadi *et al.*<sup>[21]</sup> found that the risk to staff members in the operating room was at an unsatisfactory level and required interventions to be reduced. Jahangiri *et al.*,<sup>[7]</sup> also assessed the fire risk in a few particular Shiraz hospitals and reported their findings. According to their findings, the fire risk in most hospitals was at an unsatisfactory level. In line with the findings of the current study, the research by Sarsangi *et al.*,<sup>[29]</sup> in one of Iran's hospitals demonstrated that the operating rooms' fire risk level was unsatisfactory and extremely high for participants. The findings of research by Mahdinia *et al.*,<sup>[30]</sup> are also consistent with those of the current study. In other words, according to the studies from Iran mentioned above, there are not adequate conditions for reducing the fire risk to personnel in operating rooms, and intervention programs must be implemented.

The adoption of an educational intervention to enhance personnel knowledge of the importance of fire safety and methods for fire prevention and control was another outcome of the present research. The findings indicated that both before and after the educational intervention, personnel's knowledge of fire safety had significantly increased. In addition, it was clear how this intervention affected the fire risk level and that all three parameters – risk to the building and its contents, risk to participants, and risk to activities – were decreased. The findings also demonstrated that individuals with higher levels of pre-intervention knowledge of ignition sources and fire prevention techniques benefited more from the educational intervention. Compared to the group who did not believe that fire safety during surgery was essential, those who thought it was essential had a higher knowledge score. Additionally, those who claimed to possess the necessary knowledge and expertise for managing and preventing fires scored higher on knowledge tests than those without knowledge and expertise. Additionally, those who use fire prevention techniques in high-risk surgical procedures score higher on a fire safety knowledge test than those who do not use these techniques. In addition, those who regularly apply fire extinguishing techniques as part of their occupations scored higher on fire safety knowledge tests than those in the other group. Additionally, knowledge of the position and application of the warning bell, the urgent

evacuation strategy, and the interaction between oxygen and oil have all substantially been increased among personnel both before and after the intervention. The impact of the educational intervention on the personnel's level of risk knowledge and risk tolerance is positively evaluated by all of these findings. The impact of training and control methods on decreasing the level of fire risk was evaluated in research conducted by Sepehr *et al.*,<sup>[31]</sup> in an educational complex, and it was discovered that the level of fire risk could be diminished optimally by implementing interventions. The effectiveness of safety training on the knowledge and behavior of operating room personnel in specified hospitals was examined by Davudian Talab *et al.*<sup>[24]</sup> According to their findings, safety content and educational interventions can improve operating room personnel's performance and knowledge, as well as improve future conditions that will enhance the operating rooms' fire safety. In other research projects, the impact of educational intervention on knowledge was examined by Podnos and Williams.<sup>[32]</sup> They concluded that educational intervention can enhance operating room personnel's knowledge of fire sources and positively impact the safety coefficient. Other investigations have assessed training's positive effects on enhancing hospital staff knowledge of fire safety issues, and these findings are consistent with the findings of the current study.<sup>[33,34]</sup>

The level of fire risk in selected hospitals was assessed in this research using the FRAME. As one of the more specialized approaches to assessing fire risk, this technique evaluates a number of parameters to determine the fire risk condition for buildings, personnel, and activities. Another strength of the current investigation is the incorporation of a large sample size to assess the level of knowledge in addition to implementing an educational intervention to assess the knowledge of operating room personnel throughout Isfahan hospitals. Another advantage of the research is the evaluation of all government hospitals in Isfahan City simultaneously, which demonstrates realistic findings of the investigated variables. The present study's implementation had some limitations, including the use of only educational interventions. However, a more effective way to demonstrate the impact of the interventions would be to implement engineering interventions and observe how they affect hospital risk levels. This, however, was not possible because of financial and time limitations. Eventually, it is possible to conclude that the risk acquired for personnel in hospitals was high, and given the significance of sustaining individuals' safety, this risk can be decreased through the management and engineering strategies. Of course, educational intervention decreased a portion of this risk level in this research. It is crucial to make an attempt to manage risks in operating rooms because the equipment in these spaces has significant economic value. It is suggested that educational programs be implemented as a portion of hospital regularly scheduled activities to enhance the knowledge of hospital personnel, particularly those working in operating rooms, about fire safety.

## CONCLUSION

Due to the high-risk nature associated with fire in operating rooms, it is critical to focus on fire safety in hospitals, particularly in the operating room unit. The findings of this study demonstrated the operating room personnel's level of knowledge of fire potential dangers. They stated that appropriately implementing training programs can, in addition to enhancing personnel knowledge, lower the level of fire risk and improve the operating room's safety status. Accordingly, implementing educational programs should be part of hospitals' regular operations. It is suggested to install automatic fire detection and extinguishing systems in all operating rooms of hospitals. Preparation of standard emergency exit routes, improvement of structural safety level of operating rooms, use of periodic fire risk assessment and early diagnosis of defects and training of hospital personnel in relation to knowledge of fire sources and fire prevention methods can lead to improvement of hospital safety level and patient safety.

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## Ethical considerations code

This study was a part of a thesis approved by the Ethics Committee of the Isfahan University of Medical Sciences (IR. MUI. RESEARCH. REC.1398.658). All participants were over 18 years of age, and the informed consent form for participating in the research was read and signed.

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## Conflicts of interest

There are no conflicts of interest.

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