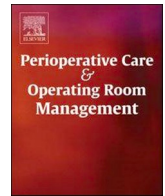




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Attitude, preventive practice and perceived barriers among perioperative and anesthesia nurses toward surgical smoke hazards during the COVID-19 outbreak

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ABSTRACT

Background: Surgical smoke (SS), which is produced by the use of high-temperature devices for cutting and coagulation of tissue during surgical procedures, is considered a serious threat to the health of operating room (OR) staff due to the presence of hazardous substances and possibility of transmitting various infections such as HPV, HIV, COVID-19 and so on. This study was conducted to determine the Attitude, preventive practice and perceived barriers among perioperative and anesthesia nurses toward surgical smoke hazards.

Methods: In this cross-sectional descriptive study, conducted at hospitals of Tabriz University of Medical Sciences (Iran) in 2021, 262 perioperative and anesthesia nurses were included by stratified random sampling. Data were collected using a demographic questionnaire and an SS questionnaire consisting of questions on attitude (17 item), practice (8 item), and barriers (13 item). Collected data were analyzed using SPSS16.

Results: The mean attitude and preventive practice scores (49.52 ± 12.36 and 15.8 ± 2.05 , respectively) of the operating room nurses were reported at moderate and weak levels, respectively. There was a direct and significant relationship between attitude and practice scores ($r = 0.129$, $P = 0.019$). The main barriers to the prevention and dealing with the hazards of SS in ORs were reported in management (3.68 ± 1.06) and equipment (3.24 ± 0.66) dimensions, respectively.

Conclusion: It is recommended to adopt strategies to improve the attitude of OR staff regarding the preventive measures against surgical smoke hazards. Moreover, appropriate equipment and support of managers should be provided by explaining the policies and guidelines to prevent the complications of surgical smoke.

1. Introduction

The operating room (OR) is a unique environment for surgical treatments and at the same time, is associated with many potential hazards for staff and patients, one of which is the exposure to a phenomenon called 'surgical smoke' (SS). SS is produced by the use of high-temperature devices, such as electrocautery, laser, ultrasonic scalpel (harmonic) and etc., which are used for cutting and coagulation of tissue during surgical procedures.¹⁻³ The use of these devices increases the temperature of tissue cells to the boiling point, and the increased intracellular pressure leads to the membrane rupture and dispersion of

the cell contents in the form of micron particles.²⁴

The US Occupational Safety and Health Administration estimates that about 500,000 health care workers are exposed to SS each year, and surgeons and OR nurses are more exposed to SS than others.⁵ In addition to water and vapor, SS contains other compounds such as cellular debris, chemicals, blood and tissues particles, viruses, and bacteria.⁶ The analysis of SS yields up to 150 types of chemicals, including benzene, hydrogen cyanide, formaldehyde, bio-aerosols, acetaldehyde, toluene, etc., with different degrees of toxicity.⁷ Additionally, in vitro studies indicate that benzene and formaldehyde have carcinogenic properties as well.⁴

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Different studies have demonstrated that prolonged exposure to SS causes respiratory problems (chronic bronchitis, asthma, and emphysema), hypoxia, nausea and vomiting, cough, dizziness and headache, airway irritation and inflammation, eye irritation and tears, cardiovascular disorders, anemia, leukemia, etc.⁸ Besides, there is a risk of transmission of human papillomavirus (HPV), acquired immunodeficiency virus (HIV), hepatitis B, hepatitis C, and Mycobacterium tuberculosis through SS inhalation for OR staff.⁹

The new coronavirus pandemic has raised concerns about the virus transmission to OR staff. This is not only related to airway intubation and extubation during anesthesia but also to the spread of potentially infectious particles present in SS. There is currently no conclusive evidence as to whether or not COVID-19 in combination with SS can be transmitted to OR staff in surgeries for patients with COVID-19. However, it has been proven that various viruses (e.g. HIV, HPV, etc.) can be transmitted through SS, thus, the transmission of COVID-19 is also possible and this necessitates the precautions by OR staff.¹⁰⁻¹²

Therefore, SS is considered a serious risk factor and threat to the health of OR staff because these people are exposed to chemicals from this smoke for an average of 7 h a day, 5 days a week, and throughout several years.^{13,14} Based on the literature, the daily effect of SS on each OR staff is estimated to be equivalent to the use of 27–30 unfiltered cigarettes.¹⁵ Ball et al. found that OR nurses who were exposed to SS for a long time experienced respiratory problems, such as bronchitis and respiratory infections, twice more than normal people.¹⁶ Besides staff, SS is dangerous for patients as well. Research has shown that SS in patients undergoing laparoscopic surgery may be absorbed through the peritoneum, causing headaches, nausea and vomiting, and prolonged patient stay at post-anesthesia care wards.¹⁴ Smoke evacuation and the use of masks are solutions provided to protect staff against the complications of smoke. Smoke suctioning is not very popular with surgeons as it is noisy and lowers the surgery speed. On the other hand, surgical masks used in the OR cannot filter the particles in SS due to their small size.^{17,18}

Therefore, in order to increase occupational safety, the beliefs, tendencies and inclinations of operating room staff towards the prevention of surgical smoke complications should be examined and strengthened, so that they can protect themselves from health problems caused by surgical smoke.⁹ The knowledge level of OR staff about SS complications was investigated in two studies and the findings indicated that the majority of them had poor information and their general and specialized knowledge was not satisfactory in this regard.⁵⁶ However, no study has been conducted to evaluate the attitude and preventive practice against the hazards of surgical smoke. One of the methods that can ensure the health of OR staff is to increase their attitude and improve their practice as these factors play an important role in preventing SS complications and ensuring the health of staff. Therefore, this study This study was conducted to determine the Attitude, preventive practice and perceived barriers among perioperative and anesthesia nurses toward surgical smoke hazards at the teaching hospitals of Tabriz University of Medical Sciences.

2. Materials and methods

2.1. Design and sample size calculations

The present study cross-sectional descriptive study aimed to determine the Attitude, preventive practice and perceived barriers among perioperative and anesthesia nurses toward surgical smoke hazards. This research was conducted at teaching hospitals of Tabriz University of Medical Sciences in Iran from November 2020 to July 2021. The study population consisted of two occupational groups of perioperative nurses and anesthesia nurses.

In this study, the sample size was determined using Cochran's formula. Since respectively 250 and 180 perioperative and anesthesia nurses worked in educational and medical centers, sample sizes of 150

and 121 individuals were calculated for perioperative and anesthesia nurses, respectively, considering an error of 5%, p and q of 0.5, and a d of 0.05.

At hospitals of Tabriz University of Medical Sciences, perioperative and anesthesia nurses were sampled by stratified random sampling. To do this, the sample size was calculated according to the abovementioned formula to obtain the total number of staff working in the OR wards of the hospitals, and then the sample size was obtained in each center. To this end, the estimated number of samples was divided by the total number of nurses, and the result was multiplied by the number of nurses in each center to determine the number of samples per center. After calculating the share of each center, sampling was performed by the simple random method using a table of random numbers.

Inclusion criteria were having at least one year of work experience in the OR and at least a bachelor's degree in perioperative and anesthesia nursing fields. Reluctance to participate in the study, incomplete response to the questionnaire questions (< 85% of the questions), and having executive and managerial positions were the exclusion criteria in this study.

2.2. Measuring instrument

The current study was designed based on the STROBE guidelines for observational studies. In this study, the instruments used to collect information consist of four sections. The first part is a questionnaire related to the personal/demographic characteristics of nurses, which were collected using a 7-item questionnaire.

The second part was a researcher-made questionnaire designed using the AORN guideline and related sources and articles^{9,19,20} to assess nurses' attitudes about the possible hazards of SS and preventive measures. It contains 17 questions (Possible hazards; 11 item and Preventive measures; 6 item) and is scored based on a 5-point Likert scale of very low (1), low (2), moderate (3), high (4), and very high (5), with a total score of 17–85. Scores of 17–39.99, 40–62.99, and 63–85 were considered negative, moderate, and Positive attitude levels regarding the hazardous effects of SS. negative and positive attitudes in "possible hazards dimension" mean that nurses' concerns about the hazards of surgical smoke are low and high, respectively.

The third part is related to the researcher-made questionnaire to assess the nurses' practice/performance on the use of preventive measures in operating rooms against the effects of SS. in this section, participants are questioned about the extent to which they take protective measures to be less exposed to SS while using electrocautery and so on in surgeries.

The practice assessment questionnaire was designed using AORN guidelines and related sources and articles.^{16,17,20,21} this questionnaire contains eight questions that are scored according to a 4-point Likert scale of never (1), rarely (2), most of the time (3), and always (4). The total score of the practice questionnaire is in the range of 8–32, and scores of 8–15.99, 16–23.99, and 24–32 were considered as weak, moderate, and good levels of practice.

The fourth section is about the questionnaire of perceived barriers to prevent SS complications, which is designed using the AORN guideline and related sources and articles.^{17,20,22} It contains 13 questions based on a 5-point Likert scale of very low (1), low (2), medium (3), high (4), and very high (5). This questionnaire examines the barriers to SS prevention in three individual-environmental (5 questions), management (3 questions), and equipment (5 questions) dimensions.

The validity of the questionnaire was assessed in two stages. In the first stage, the face validity of the questionnaire was examined and approved by 10 faculty members. Then, the CVR index was used to ensure the accuracy of the content. For this purpose, the questionnaire was submitted to 10 faculty members who were asked to select one of three options of "necessary", "useful but not necessary", and "not necessary" for each of the designed items. The received answers were calculated based on the CVR formula and its numerical value was obtained at

0.72. After determining and calculating the CVR, the questionnaire was submitted again to faculty members who were asked to comment on each item in terms of specificity, simplicity and fluency, and transparency on a 4-point Likert scale (relevant, relatively relevant, relevant, and fully relevant) to calculate the CVI. To determine the reliability using the test-retest method in a pilot study, a questionnaire was submitted to 20 operating room nurses. Three weeks later, the questionnaire was submitted to the same people to complete, and the internal consistency of the questionnaire was obtained by calculating Cronbach's alpha coefficient ($\alpha = 0.89$).

2.3. Ethical considerations

After obtaining approval from Institutional Review Board and Vice-Chancellor for Research and Technology of Tabriz University of Medical Sciences (ethical code: IR.TBZMED.REC.2021.194) and presenting it to the affiliated hospitals, the researcher referred to hospitals during the weekdays and in the morning, evening, and night work shifts, to access to all staff and after stating the study objectives individually and obtaining written consent, the questionnaire was given to qualified people and by spending the necessary time that was appropriate to the nurses' request according to the workload and speed of response, the questionnaires were completed by the nurses and finally collected by the researcher. to observe the ethical standards, the questionnaires were distributed among the participants without mentioning their names, and the participants were ensured about the confidentiality of information.

2.4. Data analysis

Data entered the SPSS16 software and were analyzed using descriptive statistics, independent *t*-test, one-way ANOVA, Linear Regression and Pearson test. $P < 0.05$ was considered as a significant level.

3. Results

From the 271 participants in the study, nine individuals were excluded from the study due to incomplete answers or systematic answers to questions, and thus 262 subjects comprised the final samples of this study.

Findings of the study about demographic characteristics showed that out of 262 participants, 147 (56.1%) and 115 (43.9%) subjects were perioperative and anesthesia nurses. The demographic characteristics are fully shown in Table 1.

A total score of 49.52 ± 12.36 was obtained for nurses' attitudes about SS complications. As shown in Table 2, in the dimension of possible hazards of surgical smoke inhalation, nurses were most concerned about the possibility of COVID-19 transmission through surgical smoke (3.55 ± 1.07). in the dimension of preventive measures, 76% of nurses believe that "using a proper ventilation system to ventilate the OR at least 15 times/h" can have a significant impact on reducing the possible hazards of surgical smoke.

The attitude scores were at the moderate (40–62.99), negative (17–39.99), and positive (63 to 85) attitude levels for 67.94, 19.08, and 12.98% of nurses (Fig. 1).

The results of the Pearson correlation test revealed that the attitude score had a significant negative correlation with the age variable ($r = -0.149$, $P = 0.016$) so that an increase in the age of nurses led to a decrease in their attitude score toward SS complications.

The results of the *t*-test and ANOVA showed that attitude scores were not significantly correlated with the other demographic characteristics (occupational group, gender, marital status, working hours, and work experience) ($P > 0.05$).

The total score (15.8 ± 2.05) of nurses' preventive practice against the hazards of SS in operating rooms indicated a weak level. As shown in Fig. 2, the practice scores were at levels of moderate (16–23.99), weak

Table 1

Frequency distribution of participants according to demographic characteristics.

| Variables | Frequency | Percentage |
|------------------------|----------------|----------------|
| Occupational groups | | |
| Perioperative nurse | 147 | 56.1% |
| Anesthesia nurse | 115 | 43.9% |
| Gender | | |
| Male | 123 | 46.9% |
| Female | 139 | 53.1% |
| Marital status | | |
| Single | 87 | 33.2% |
| Married | 175 | 66.8% |
| Working hours per week | | |
| 45> | 47 | 17.9% |
| 45 | 112 | 42.7% |
| 45< | 103 | 39.3% |
| Work experience (year) | | |
| 1–5 | 145 | 55.3% |
| 5–15 | 78 | 29.8% |
| 15< | 39 | 14.9% |
| Quantitative Variables | | Mean \pm SD* |
| Age (year) | 35.1 \pm 8.6 | |

*Standard Deviation.

(98–15.99), and good (24–32) in 58.78, 40.08, and 1.14% of nurses, respectively.

According to Fig. 3, the highest average values of preventive measures belonged to "use of surgical masks" (3.473 ± 0.61) and "use of high-filtration masks such as N95" (2.698 ± 0.7), respectively. Moreover, the lowest average values of preventive measures were recorded for "using suction with in-line filters to evacuate SS" (1.126 ± 0.42) and "using a proper ventilation system to ventilate the OR at least 15 times/h" (1.21 ± 0.48), respectively.

The results of the Pearson test indicated that the practice scores were not significantly correlated with the age variable ($r = 0.032$, $P = 0.607$). The results of the *t*-test and ANOVA revealed that practice scores had no statistically significant relationships ($P > 0.05$) with the other demographic characteristics (occupational group, gender, marital status, working hours, and work experience). significant positive correlation was found between the nurses' practice and attitude scores ($r = 0.129$, $P = 0.019$) based on the Pearson test results. As such, preventive practice scores of nurses increase with increasing their attitudes to the hazards of SS and the prevention methods.

The increase in the total practice score of nurses by increasing one score to the total attitude score was investigated using the simple linear regression analysis. The results showed that by increasing one unit to the average of the attitude score, the practice score increases by 0.21 (Fig. 4).

The mean score obtained for each dimension of barriers to the prevention of SS complications from the viewpoints of nurses was determined in this study. According to these results, the highest (3.688 ± 1.06) and the lowest (3.08 ± 0.68) average scores were recorded for the dimensions of managerial barriers and individual-environmental barriers (Fig. 5).

Based on the results of Fig. 6, the highest average scores of barriers to the prevention of SS complications were respectively obtained for "the lack of equipment and facilities to prevent SS complications" (4.03 ± 0.82), "the lack of policies and guidelines to support the use of smoke suction equipment" (3.95 ± 1.12), "the lack of support for managers to use different preventive methods for the hazards of SS" (3.92 ± 1.18), and "insufficient staff knowledge of SS complications" (3.81 ± 0.9).

4. Discussion

The results of the present study demonstrated a moderate level of OR nurses' attitudes about the hazards of SS and the preventive measures. In

Table 2
Descriptive results of dimensions and items of nurses' attitude about surgical smoke.

| Item | | Low/ very low N(%) | Moderate N(%) | High/very high N(%) | Mean | SD | |
|------------------------------------|--|-----------------------|------------------|------------------------|------|------|-------------------|
| Possible Hazards of Surgical Smoke | How dangerous do you think the complications of surgical smoke can be? | 70(26.7) | 95(36.3) | 97(37) | 3.08 | .89 | 30.8 ± 9.2 |
| | How likely are you to get cancer from inhaling surgical smoke? | 157(59.9) | 90(34.4) | 15(5.7) | 2.25 | .84 | |
| | How likely are you to get pulmonary disease from inhaling surgical smoke? | 50(19.1) | 96(36.6) | 116(44.3) | 3.35 | 1.09 | |
| | How likely are you to get infectious diseases from inhaling surgical smoke? | 135(51.5) | 81(30.9) | 46(17.6) | 2.53 | .92 | |
| | How likely are you to get HIV and hepatitis from inhaling surgical smoke? | 144(55) | 71(27.1) | 47(17.9) | 2.37 | 1.05 | |
| | How likely are you to get into COVID-19 as a result of inhaling surgical smoke? | 45(17.2) | 89(34) | 128(48.8) | 3.43 | 1.04 | |
| | How concerned are you about the carcinogenicity of surgical smoke? | 170(64.9) | 67(25.6) | 25(9.6) | 2.15 | 1.02 | |
| | How concerned are you about transmitting the infection through surgical smoke in the operating room? | 157(59.9) | 80(30.5) | 25(9.5) | 2.23 | .94 | |
| | How concerned are you about HIV and hepatitis transmission through surgical smoke in the operating room? | 144(55) | 71(27.1) | 47(17.9) | 2.47 | 1.00 | |
| | How concerned are you about the destructive effects of surgical smoke on your respiratory system? | 59(22.5) | 81(30.9) | 122(46.6) | 3.34 | 1.13 | |
| Preventive measures | How concerned are you about transmitting the COVID-19 through surgical smoke in the operating room? | 47(17.9) | 66(25.2) | 149(56.8) | 3.55 | 1.07 | |
| | How useful do you think the use of personal protective equipment such as gowns, hats and glasses is to protect the surgical team from the hazards of surgical smoke? | 186(71) | 70(26.7) | 6(2.3) | 2.12 | .73 | 18.7 ± 4.2 |
| | How useful do you think the use of surgical masks is to protect the surgical team from the Hazards of surgical smoke? | 165(63) | 75(28.6) | 22(8.4) | 2.30 | .86 | |
| | How useful do you think using high-filtration masks like N95 is to protect the surgical team from the hazards of surgical smoke? | 34(13) | 44(16.8) | 184(70.2) | 3.75 | 1.08 | |
| | How useful do you think the use of suction without in-line filters is to protect the surgical team against the hazards of surgical smoke? | 97(37) | 126(48.1) | 39(14.9) | 2.78 | .87 | |
| | How useful do you think the use of suction with in-line filters is to protect the surgical team against the hazards of surgical smoke? | 33(12.6) | 65(24.8) | 164(62.6) | 3.71 | 1.12 | |
| | How useful do you think ventilating the operating room at least 15 times per hour is to protect the surgical team from the hazards of surgical smoke? | 22(8.4) | 41(15.6) | 199(76) | 4.03 | .98 | |
| | Total mean | | | | | | |

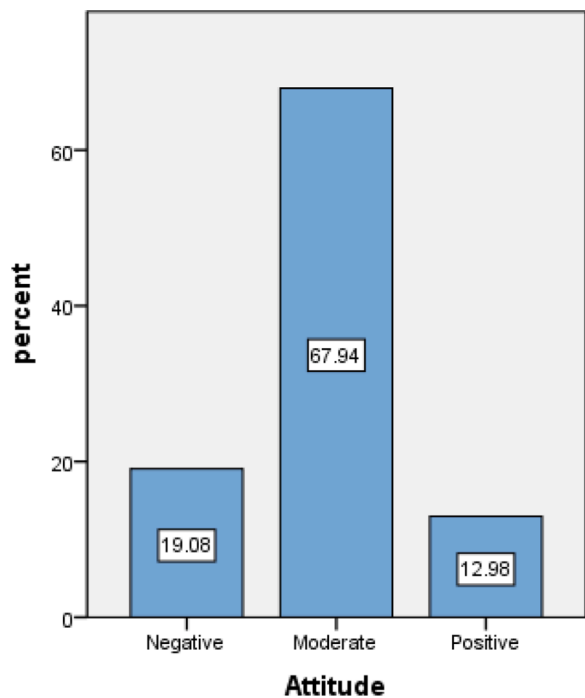


Fig. 1. Nurses' attitudes toward the effects of surgical smoke based on three levels of positive, moderate, and negative.

other words, most of the studied nurses presented moderate concerns about developing asthma, chronic cough, lung disease, and infections such as HPV, hepatitis B, COVID-19, etc. due to prolonged exposure to SS. In a study by Michaelis et al.,¹⁵ 88% of nurses showed a positive attitude about the hazards of SS complications when they did not observe the use of personnel protective equipment (PPE) and

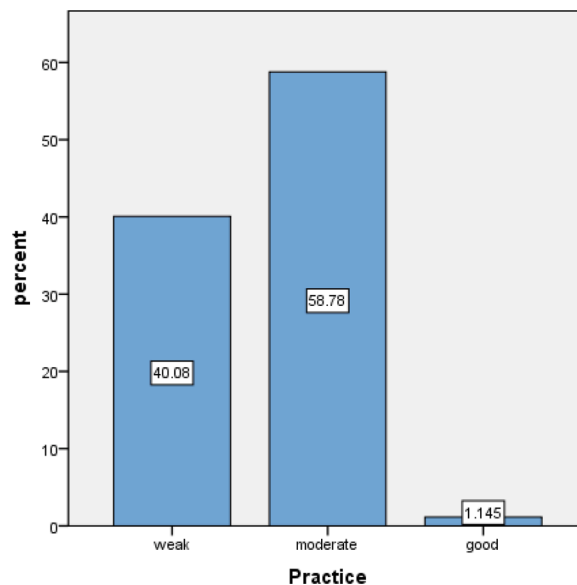


Fig. 2. Preventive practice status against surgical smoke complications based on three levels of good, moderate, and weak.

appropriate preventive precautions. Similarly, Spearman et al.²³ reported that 91% of OR nurses were concerned about the hazards of SS, and Vortman et al.²² found that all OR nurses had a positive attitude toward the hazards of SS.

Also, according to the results, strengthening the attitude of Iranian nurses about the importance of preventive measures against the hazards of surgical smoke seems necessary, which can be achieved by training and increasing the knowledge of nurses regarding the preventive measures. Since attitudes influence various aspects of social life, communication, and other issues and can guide one's practice in dealing with

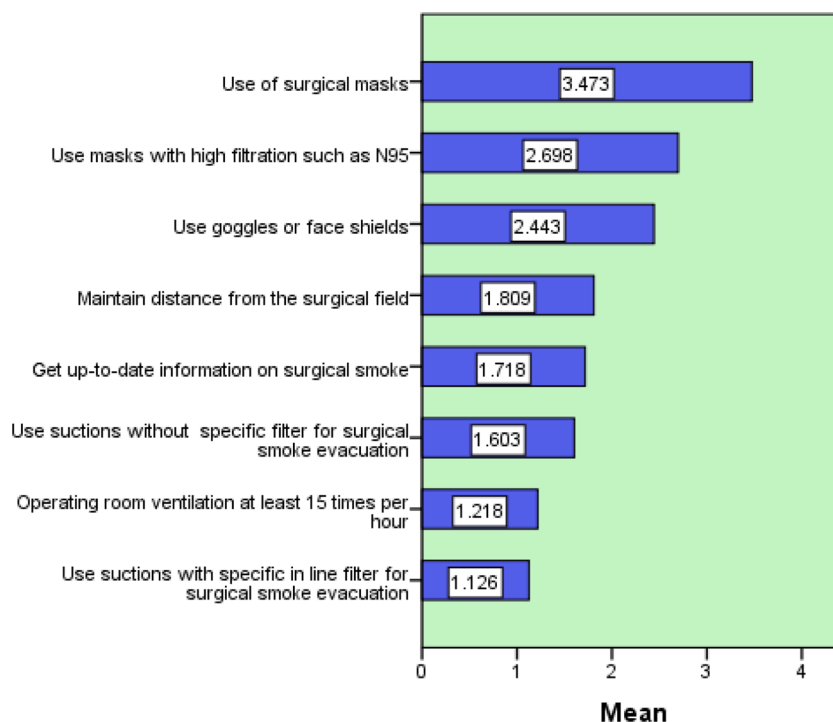


Fig. 3. Scores of items related to the preventive practice/ measures variable.

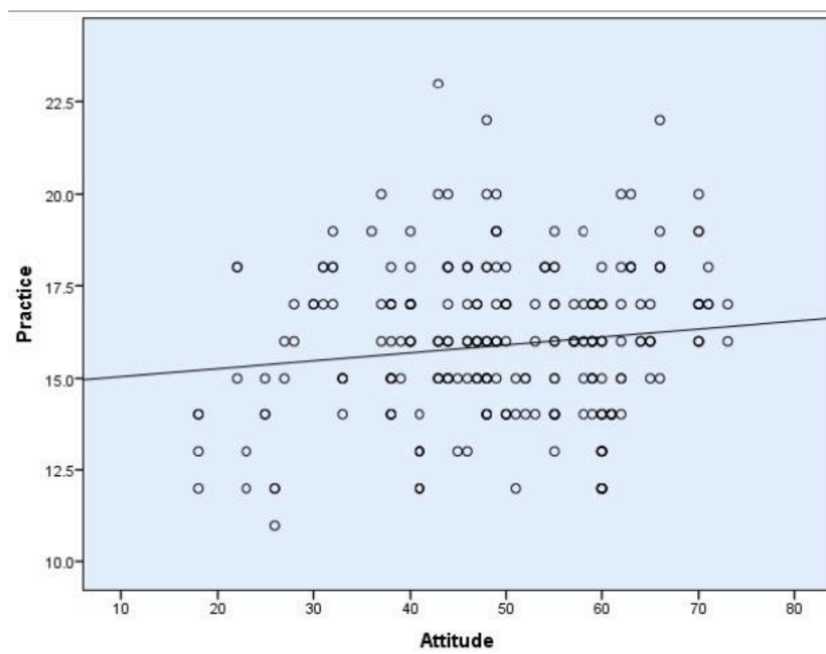


Fig. 4. A significant relationship between attitude and practice.

various issues, improving the attitudes of nurses, OR staff and hospital managers about the importance of preventive measures against surgical smoke can direct their behavior and decision-making during surgical procedures in this regard.

Concerning the preventive behaviors against complications and risks of SS in the OR, the results showed that "the use of surgical masks" and "the use of high-filtration masks such as N95" were the two measures observed by operating room nurses. Moreover, "using suction with in-line filters to suck SS" and "using a proper ventilation system to ventilate the OR at least 15 times/h" were respectively the two measures of

less observance.

As reported by Vortman et al.,²² most nurses believed that the use of masks, in particular high-filtration masks, was sufficient to protect OR staff from the complications and dangers of SS and was the main protective method against SS. As shown in various studies,^{24,25} this is not safe. although a high filtration mask filters particulate matter that is 0.1-µm in size and larger, it does not create a seal around the face. Wearing PPE such as a fit-tested N95 is recommended as a secondary line of defense against the inhalation of SS when respiratory protection is required based on the type of procedure. For example, the Centers for

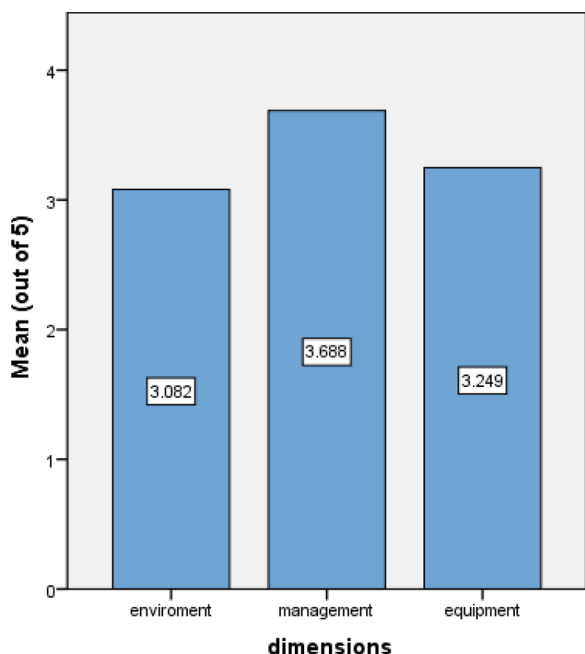


Fig. 5. Average scores of the dimensions of barriers to the prevention of surgical smoke complications.

Disease Control and Prevention²⁶ recommends respiratory protection be worn by all team members present for cough-inducing procedures in patients known with or suspected of having Mycobacterium tuberculosis.

It is important to note that high filtration masks are less effective than an N95 respirator.²⁰ Further, a fit-tested N95 respirator alone is not a recommended substitute for SS evacuation; therefore, SS evacuation should remain the first line of defense. SS evacuation using methods

such as using suction with in-line filters to evacuate SS and using a suitable ventilation system to ventilate the OR at least 15 times/h are essential as the first line to deal with the effects of SS. Neither type of mask protects against the health effects of SS.²⁰

Furthermore, the present results showed that a direct and significant relationship between the mean scores of attitude and practice. It is believed that all three dimensions of knowledge, attitude, and practice should be strengthened to produce the desired effects. Knowledge alone does not lead to a sustained good practice, but attitudes must change as well, and the people’s beliefs must be structured deeply and scientifically for a continued proper practice.²⁷ Indeed, measures should be adopted that, in addition to raising the knowledge level of nurses, nursing managers, and other medical staff in this area, can create a positive attitude in them, and this attitude can lead to an ideal and appropriate practice in preventing SS complications and, finally, improving the safety of OR staff.

According to our findings, among the various barriers to the use of preventive strategies against complications caused by SS inhalation, the "lack of equipment and facilities in the OR to prevent SS complications" was introduced as the main barrier from the nurses’ viewpoints. In the study of Vortman et al.²² conducted in the United States, the main barrier from the nurses’ viewpoint was introduced to be "the lack of research and required information about long-term consequences of exposure to SS", which is not consistent with our results. In developing countries such as Iran, the major problem seems to be the lack of proper equipment to evacuate SS. Vortman et al.,²² on the other hand, stated that appropriate equipment was readily available in ORs but are not used for various reasons, such as surgeons’ resistance and making a loud noise. The individual smoke evacuator and the centralized smoke evacuation system are some of the equipment recommended in different guidelines for evacuating SS from the OR.

When greater amounts of surgical smoke are generated, an individual smoke evacuator is used. Individual smoke evacuators have filtration systems that include a charcoal filter and an ultra-low penetration air (ULPA) filter. The charcoal filter removes toxic gasses and odor, whereas

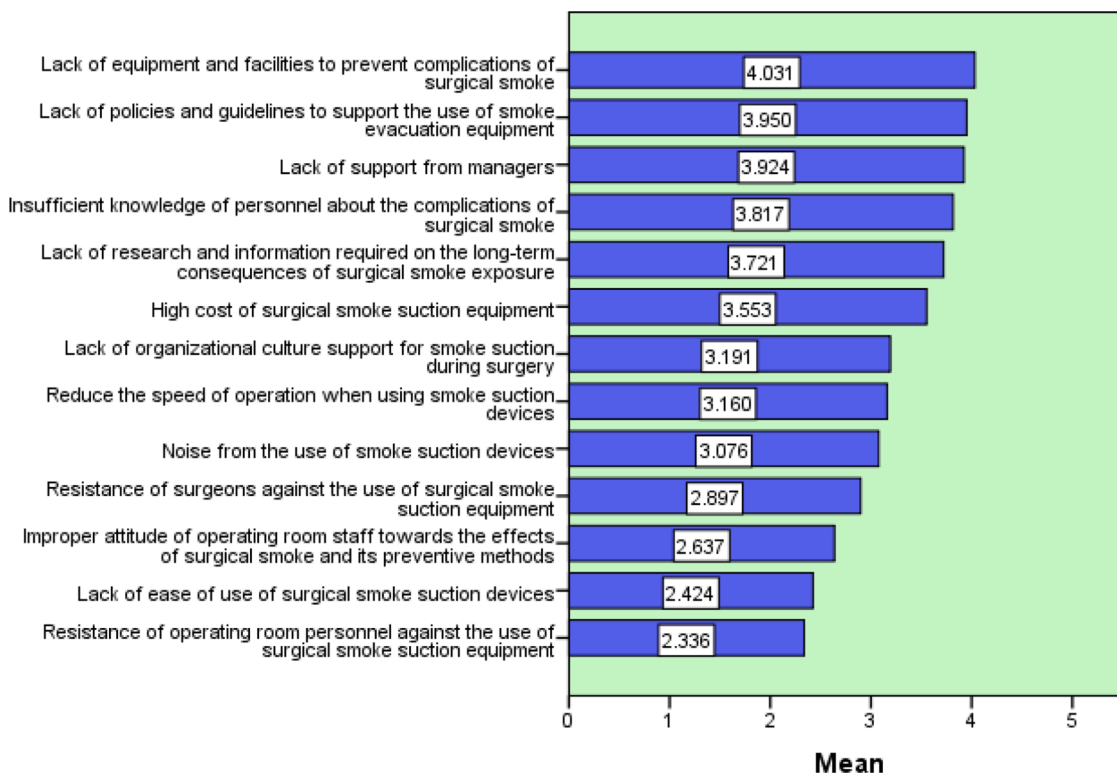


Fig. 6. Average values of items for barriers to the prevention of surgical smoke complications.

the ULPA filter removes small particulates with filtration of 0.12micron size matter at 99.9999% efficiency.¹⁶

Centralized smoke evacuation systems provide smoke evacuation for several surgical rooms at the same time. The smoke evacuation line needs to be routinely flushed and cleaned to prevent debris buildup and pathogen growth within the system. A central system is convenient because it is always available; however, if it malfunctions, smoke evacuation is not available to multiple surgical areas.²⁸

The second barrier from the nurses' viewpoint was the "lack of policies and guidelines to support the use of smoke suction equipment". To remove this obstacle, in addition to providing appropriate equipment for smoke evacuation in the OR environment, the presence of evidence-based guidelines and policies on dealing with occupational hazards, such as SS in the OR, can reduce the risks and occupational injuries to increase the safety of staff and even patients.

The "lack of support from managers to use different preventive methods against the hazards of SS" was the third effective factor in preventing the use of appropriate strategies against the effects of SS from the viewpoints of nurses. The officials' lack of belief and support for the use of various preventive methods to deal with the effects of SS is a barrier that may result from their lack of knowledge about the occupational hazards of SS and the importance and effectiveness of using protective approaches in maintaining OR staff safety and improving the quality of medical care. In this regard, it is recommended to hold meetings with high-ranking officials and administrators of the Ministry of Health, heads of hospitals, and nursing managers to clarify the importance of using appropriate equipment to protect personnel against the effects of SS and other occupational hazards.

The insufficient knowledge of staff about the effects of SS was another major barrier introduced by the participants. Likewise, Vortman et al.²² reported this case as one of the main barriers to prevent SS complications in ORs, and about 70% of the participants agreed that the unawareness of staff was one of the main barriers. Insufficient knowledge of staff about the effects of surgical smoke has been reported in several studies. Khoshdel et al. (2019) claimed that 75% of surgical team members had weak awareness of this issue.⁵ Clark et al.²⁹ also found low awareness of surgeons about the effects of cautery smoke. In this regard, Ball (2010) reported that awareness about the side effects of cautery smoke was directly correlated with its evacuation, and training programs could create an environment free of cautery smoke.¹⁶¹⁹ Numerous studies have emphasized that the surgical team exposed to cautery smoke should be aware of its side effects. Therefore, the surgical team should not only consider its short-term complications, such as the burning of the mucous membranes and vision but should also address its long-term risks.³⁰

4.1. Study limitations

Lack of similar research on "Attitude, preventive practice and perceived barriers among perioperative and anesthesia nurses toward surgical smoke hazards" to compare and interpret the results was the main limitation of this study. Another limitation of this study was using a questionnaire, which has a self-report aspect, to collect the data. Thus, the answers might be affected by incorrect answers and staffs' lack of confidence in the implementation of research project results, leading to reduced commitment to provide honest answers to the questionnaire questions. The researcher tried to convince them to participate in the study by discussing and explaining the importance of the results to improve the existing conditions.

5. Conclusion

The present results demonstrated that the attitudes of OR nurses about the hazards of SS and the prevention methods and the level of preventive practice in ORs were at moderate and weak levels, respectively. Furthermore, the management and equipment were the most

reported main barriers to prevent and deal with the hazards of surgical smoke in ORs. A positive attitude toward the importance of preventive measures against the hazards of surgical smoke has a direct relationship with its evacuation. Therefore, it is recommended to improve the attitudes of employees by such strategies as holding courses and workshops, providing educational materials on websites of universities and faculties, pamphlets, and brochures so that surgical smoke hazards prevention is considered a serious approach. Besides, attempts should be made to create a safe and risk-free environment by providing appropriate equipment and supporting managers to use various methods to prevent the hazards of surgical smoke by explaining the policies and guidelines.

CRedit authorship contribution statement

Mojgan Lotfi: Supervision, Writing – original draft. **Zahra sheikhali-pour:** Conceptualization, Methodology, Writing – original draft, Data curation. **Vahid Zamanzadeh:** Supervision, Writing – original draft. **Ahmadmirza Aghazadeh:** Formal analysis, Data curation. **Hassan Khordeforoush:** Visualization, Investigation, Software, Data curation. **Parvin Rahmani:** Visualization, Investigation, Software, Data curation. **Omid Zadi akhuleh:** Conceptualization, Methodology, Writing – original draft, Data curation.

Declaration of Competing interests

No, there are no competing interests for any author.

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Ethical approval

The project's compliance with the ethical code was approved by the Ethics Committee of Tabriz University of Medical Sciences (IR.TBZMED.REC.2021.194).

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