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ORIGINAL RESEARCH ANESTHESIOLOGY

Threats to operating room personnel's occupational safety and health: a qualitative study

Mina Amiri Dore [1], Camellia Torabizadeh [2]*, Zahra Keshtkaran [3]

Author affiliation:

1. Student Research Committee, Shiraz University of Medical Sciences, Shiraz, Iran; E-mail: Minaamiri753@gmail .com
2. Community Based Psychiatric Care Research Center, Department of Nursing, Shiraz University of Medical Sciences, Shiraz, Iran; E-mail: torabik@sums.ac.ir
3. Department of Nursing, Shiraz University of Medical Sciences, Shiraz, Iran; E-mail: Keshtkara.zara@yahoo.com

Correspondence: Camellia Torabizadeh {ORCID: 0000-0003-2193-5844} E-mail: camellia_torabizadeh@yahoo.com, torabik@sums.ac.ir

Abstract

Background & Objective: Every operating room has been associated with a variety of occupational hazards, but not many studies have been conducted to assess and address these hazards. We used a qualitative approach to explore operating room personnel's experiences of workplace hazards and how these hazards threaten their occupational safety and health (OSH).

Methodology: This qualitative study was conducted in five teaching hospitals in the south-west of Iran from February 2019 to March 2021. The sample was 24 operating room personnel who were selected under convenient sampling technique. Data were collected using semi-structured, individual interviews, document review and non-participant observation. The collected data were analyzed according to the qualitative content analysis method using MAXQDA v. 2020.

Results: After prolonged analysis of the data, the researchers extracted 644 codes, 13 subcategories, 4 categories, and 1 main theme. The main theme of the study was working in a context of occupational hazards.

Conclusions: Operating rooms are full of potential dangers, which, when combined with the personnel's negligence and management inefficiencies, increase the risk of occupational health and safety. Therefore, making working conditions safe by providing adequate personal protective equipment (PPE), in-service training, and identifying and managing the causes of personnel negligence are recommended. Moreover, strategies should be introduced to manage stress and conflicts among the healthcare personnel, thus controlling psychological hazards.

Abbreviations: OSHA - Occupational Safety and Health Administration; OSH - Occupational Safety and Health; HEPA - High-efficiency particulate absorbing filters; ORP - Operating room personnel

Key words: Occupational; Safety, Health; Operating room; Nursing

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1. Introduction

The healthcare personnel face a variety of serious occupational hazards, which can result in injuries and illnesses in this population. According to the statistics released by Occupational Safety and Health Administration (OSHA) over 582,800 cases of injury and illness were recorded for the healthcare personnel in 2017, which number was 153,900 cases more than in other industries. [1]

According to the American Association of Surgical Technologists, modern operating rooms (OR) are complex, technologically-advanced environments where many precautions must be taken for the safety of the operating room personnel (ORP). [2] Many surgeries are

invasive and the instruments employed to cut the patients' tissues are dangerous to the staff. [3]

Another significant occupational hazard in hospitals is violence, [4] which can take different forms, among them aggression, verbal abuse, indifference, trivialization, accusation and deprecation, criticism and threats. [5]

Operating room staff and physicians are faced with a variety of occupational safety and health[OSH] hazards, most of which are widely known, but their causes vary and need to be investigated. Understanding individuals' experiences and perceptions through qualitative research is an effective way to obtain knowledge from a context-specific perspective, [6] and identify, describe or explore a concept and its characteristics. [7]

A review of literature shows that, to date, no qualitative research has been conducted into the factors, which affect the OSH of the personnel in OR. Accordingly, the present study aims to explore the threats to the OSH of the ORP.

The goal of qualitative research is to gather rich new data and present cultural-contextual descriptions and interpretations of social phenomena. [8] Qualitative research allows individuals to freely express their experiences, perceptions, beliefs and values. [7, 9]

We explored ORP's experiences of workplace hazards and how these hazards threaten their occupational safety and health (OSH) in this study using a qualitative approach and the conventional content analysis method suggested by Graneheim and Lundman for data analysis. [9]

2. Methodology

The study was conducted in 5 teaching hospitals in the fifth largest city of Iran located in the south-west of the country from February 2020 to March 2021.

The participants were 24 ORPs, who were selected via purposeful sampling. Sampling continued to the point of data saturation, i.e. no new data could be collected, the categories and subcategories became saturated, and the relationships between the categories and subcategories were comprehensible.

The inclusion criteria were at least one-year working experience in OR and being willing to participate in the study. The exclusion criterion was withdrawing from the study during the study. The participants were selected from diverse demographic backgrounds in terms of age, gender, marital status, job position, education, and duration of work experience (Table 1).

Data were collected for 11 months through in-depth, semi-structured interviews, non-participant observation, and document review. Each interview began with a few general questions, e.g. 'What does the concept of OSH mean to you?' and 'What are your experiences regarding OSH in the operating room?' Based on the participants' responses, more specific questions were asked, including 'How did you feel when you received …?' and 'What factors affect your OSH?' The participants' experiences were explored further by such questions as 'Would you explain more?' or 'Can you give me an example'. The time and place of the interviews were chosen by agreement with the participants. Each interview lasted approximately 60-80 min. In total, 24 interviews were conducted, recorded and analyzed.

For document review, the researchers examined the accreditation documents of the hospitals, the personnel's occupational health and periodic health examination checklists, the ORP's job responsibilities, and the curriculum for a bachelor's degree program in surgical technology. The documents were coded to facilitate data analysis. To examine the ORP's performance and their working conditions, the researchers conducted non-participant observations in 10 shifts, for 5 hours each time. The observations were recorded and coded as field notes, which were later used in data analysis to add to the richness of the results.

In the present study, the rigor of the qualitative data was evaluated using the four criteria of credibility, transferability, dependability and confirmability (TACT framework). [10] To increase the credibility of the data, the researchers used various methods, namely: prolonged engagement, triangulation (data sources and research method), use of multiple methods for data collection (individual interviews, document review and non-participant observations), and member check. Credibility was also increased through focus on study, selection of an environment which matched the research objective, selection of participants with varying experiences, use of questions which addressed the various aspects of the concept under study, and maximum variation sampling in terms of age, gender, work experience and job title. By providing a detailed description of the results and selecting a diverse sample, the researchers tried to ensure the transferability of the findings to larger populations. Thorough descriptions of the participants' demographic characteristics and experiences, the study context, and the researchers' observations throughout the study were included. To ensure the dependability of the results, the researchers precisely explained how the research was conducted in the methodology section and provided the initial codes extracted from analyses of the participants' experiences, along with examples of the manner of theme extraction and selections of the interviews for each theme to make it more tangible. Toward ensuring confirmability, the researchers documented all the data collected in every step of the study. The data were controlled and peer reviewed by two qualitative research experts and professors from the departments of

occupational hygiene, psychology, literature and management. The comments of the panel of experts were used to make the necessary revisions.

The present study has been approved by the medical ethics committee of the university. At the beginning of the study, the participants were informed about the objectives of the study and asked to sign the informed consent form. The participants were also informed that all information would be confidential and anonymous. Participation was on a voluntary basis and the participants could withdraw from the study at any point.

Data Analysis

The collected data were analyzed according to Graneheim and Lundman's method. [9] Each transcript was read through several times so that the researchers could get a general idea of the whole script and extract its theme. If there were any ambiguities, the researchers would ask the participants to explain what they meant. Next, meaning units were extracted and coded. Based on their similarities and differences, the codes were classified into categories. MAXQDA v. 2020 was also used for data analysis.

3. Results

The participants were 24 ORP with different job titles. The majority of the participants were female (58.33%), married (70.83%), and had a bachelor's degree (54.1%). The participants' mean age and work experience were 36.47 and 13 years respectively (Table 1).

Table 2 shows an example of a meaning unit and its condensed meaning units and codes extracted from the interview transcripts.

After the data were analyzed, 750 codes emerged, which number fell to 644 after repeated codes were merged. Subsequently, through prolonged engagement with the data and a reduction process, 13 subcategories, 4 categories and 1 main theme emerged (Table 3).

Working in a context of occupational hazards

The theme of working in a context of occupational hazards consists of the following categories: inevitable physical hazards, disregard for the principles of occupational safety, psychological hazards, and inefficient management.

Inevitable physical hazards

This category consists of the subcategories of 'exposure to biological pathogens', 'exposure to harmful chemicals', 'risk of ergonomic hazards', and 'risk of hazards in the physical environment'.

Exposure to biological pathogens

Among the biological issues which the participants were frequently faced with were dealing with patients with infectious diseases, e.g. hepatitis C, Acinetobacter, bovine spongiform encephalopathy (BSE), and acquired immunodeficiency syndrome (AIDS), contaminated sharp objects, blood and other bodily fluids, pathogens transmitted by electrosurgical smoke and respiratory diseases:

21: In the vascular surgery section, most of our patients are in need of emergency operations; last year, we had to deal with influenza A virus subtype H_1N_1, and this year it's the Coronavirus disease (COVID-19).

In addition, many of the patients on dialysis have either AIDS or hepatitis C. The participants also referred to repeated encounters with COVID-19 patients and absence of viral test results for patients in need of emergency care.

Another issue mentioned by many of the participants was being pricked by contaminated surgical needles, angiocaths and poorly made glass ampules in ORs:

3:'I've been needled many times myself, when inserting triple lumens, central venous pressures [CVP] or arterial lines'.

Exposure to harmful chemicals

The participants' experiences showed that one of the causes of inevitable physical hazards in ORs is exposure to harmful chemicals that include hazardous gases, medicines and substances, as well as fumes from cleaning agents and disinfectants:

5: 'Inhaling the vapors of the formaldehyde which we commonly use to preserve patients' pathological tissues is dangerous; it's carcinogenic'.

The spirometry test results of some of the participants showed that inhalation of anesthetic gases had reduced their lung capacity:

4: 'In their periodic examinations, some of the anesthetists hardly have 50% of their expected lung capacity when they come in for spirometry'.

Exposure to high doses of chemotherapy drugs in the course of chemotherapy procedures with cardiopulmonary bypass was another issue referred to by the ORP. Some of the participants mentioned repeated exposure to disinfectants and latex powder:

8: 'I'm allergic to the latex powder in gloves. It makes my skin crack and bleed. After each operation, I have to use topical anti-inflammatory ointment.

Risk of ergonomic hazards

Such factors as having to stand for long periods, inevitable poor posture, and having to move heavy objects were among the ergonomic hazards that the

participants mentioned. The results showed that having to bend their necks to focus the lens of surgical loupes and bending over patients' bodies in abdominal surgeries had inflicted ergonomic injuries on the ORP, including cervical radiculopathy, cervical disk herniation, back pains and rounded shoulders. In addition, having to press on retractors for long periods had caused pain and inflammation in the personnel's wrists. The anesthetists' wrist hyper flexion while holding masks and using laryngoscopes had resulted in their suffering from carpal tunnel syndrome [CTS]:

4: 'The ORP's posture is really bad. They often have to stand for long hours or slouch their shoulders; they have pains in their necks and wrists'.

Some of the participants mentioned that moving heavy sets and pieces of equipment, carrying unconscious patients and dragging gurneys instead of pulling them put the personnel at risk of ergonomic hazards.

Risk of hazards in the physical environment

Hazards in the physical environment of ORs are often due to the substandard design of ORs. Such issues as substandard construction plans and materials put the personnel at risk of repeated exposure to x-ray, fire incidents, and overexposure to the heat and light of the surgical equipment:

17: 'This building used to be a laboratory 25 years ago; that's why it's not standard, the rooms are too small, the personnel are always bumping into the equipment, or things are dragged over their feet'.

Moreover, excessive use of x-ray in certain operations increase the personnel's exposure to x-ray:

19: 'In the orthopedic operating room, the residents use the fluoroscopy so much that sometimes the machine shuts down. Recently, in a surgery, the patients had been exposed around 300 times'.

Based on the experiences of the ORP, damaged light switches and power outlets, shortage of power outlets, lack of ceiling-mounted extension cords and outdated electrical power systems are among the major risk factors in ORs:

17: 'Two years ago, a drip spilled into a distributor and started a fire. It was right next to an oxygen tank. If the tank hadn't been shut, a terrible explosion sure would have happened'.

Lack of the necessary infrastructure for ventilation was observed in most of the ORs:

17: 'One of the biggest problems here is lack of ventilation. The passageways are 40 or 50 years old, or there is a ventilator, but it is broken which means zero ventilation'.

Disregard for the principles of occupational safety

This category consists of the subcategories of negligence in using, collecting, and disposing of sharp objects, disregard for the principles of sanitizing the surgical environment and instruments, disregard for periodic check-ups and on-the-job training, and failure to use personal protective equipment (PPE).

Negligence in using, collecting, and disposing of sharp objects

Examples of negligence in handling sharp objects were attaching blades to scalpel handles by hand rather than a clamp, leaving sharp objects on the scrub tray or in patients' sheets, not removing the batteries of cordless drills and saws, leaving dermatome blades on their handles, and dumping sharp objects in trashcans:

9: 'When the sets are brought back to the set room, we see that the personnel haven't removed the blades, or the needles are still in the needle holders.

Disregard for the principles of sanitizing the surgical environment and instruments

Some examples of negligence were related to sanitizing and disinfecting the operating room environment and surgical tools. These instances of the personnel' deliberate or unintentional negligence could be traced to shortage of mop cleaning areas and lack of cleaning cloths:

11: 'One of the principles of emptying a surgical suction pump jar is you should put on new gloves. But the housekeepers use the same gloves they use to clean the room to empty the surgical suction pump jar'.

Failure to comply with the principles of washing and sanitizing surgical tools by hand takes different forms:

22: 'Sometimes, the personnel do not sanitize the equipment that hasn't been used in the field and is brought back untouched and send it straight for packing. This is a great error and increases the risk of biofilm'.

Disregard for periodic check-ups and on-the-job training

The majority of the personnel were not concerned about the shortcomings in their professional skills and knowledge and, despite their superiors' recommendation, did not participate in the job orientation programs and examinations. The participants' experiences showed that the personnel completed their health files with indifference and shrank from their periodic check-ups for reasons of having to work overtime, self-evaluating their issues, having access to specialists in the operating room, and fear of stigma.

Failure to use personal protective equipment

The researchers observed many cases of negligence in the use of PPE. This negligence was occasionally due to ignorance, but in some cases, the personnel did not comply consciously:

8: 'Once, I saw one of my colleagues who was wearing open toe slippers cut his tendon when a blade fell off the back table and went straight into his foot'.

Failure to wear gloves despite skin injury and not wearing masks while using detergents were other examples of the personnel's negligence in using PPE.

Some of the personnel were negligent in wearing lead glasses or aprons:

8: It is wrong to work without proper protection, but sometimes you have to work for a long time while you're wearing a heavy apron and wearing a gown over that. It gets too hot; you sweat and get impatient, so you just prefer not to wear it at all.

Psychological hazards

This category consists of the subcategories of anxiety about complications in patients' conditions, exposure to violence, and perception of inter-professional discrimination.

Anxiety about complications in patients' conditions

The participants repeatedly referred to such stressful circumstances as rapid deterioration in patients' health conditions and being witness to terrifying scenes:

14: Our job has to do with patients' lives and we are always under stress. I mean, for example, stopping severe bleeding in an emergency, it takes a lot of effort to make the patient's condition stable. Very often, all the stress gives me palpitations.

Occasional encounters with severely ill patients who are in immediate need of intubation in the COVID-19 pandemic can increase the personnel's stress level, so much so that they may forget about their own health and begin intubation without full PPE.

The participants' traumatic experiences included seeing the crushed tissues of the abdomen and genitals of a man stuck in a propeller, the sight of a patient electrocuted by a high-voltage current and having to amputate all his limbs, seeing the severed fingers of a child whose hand had been stuck in an elevator door, and being witness to severely ill patients' bidding their families farewell:

14: 'Because of the nature of our job, we witness a lot of pain and suffering in our patients. Now, if a patient dies in front of our eyes, we are affected emotionally for several days'.

Exposure to violence

The findings of the study showed that verbal and physical violence, being ignored, and bullying were examples of violence in ORs. Verbal and physical violence between the personnel of different ranks was repeatedly observed in the field:

19: 'I was witness to a quarrel between two of the personnel. One of the personnel started quarreling with the manager because he had given him the day off without telling him'.

The participants' experiences showed that surgeons' insulting and belittling the personnel or treating them with anger during surgery can result in poor concentration and, in turn, increase the risk of occupational hazards for the personnel.

Perception of inter-professional discrimination

In the present study, the doctors' overbearing attitude, inequitable distribution of break rooms among the employees of different ranks, and obvious differences in salaries and perquisites were the main causes of the ORP's perceived discrimination. The participants' experiences showed that doctors' obvious superiority in the healthcare system results in their self-importance and inability to communicate with the personnel. The doctors' arrogance toward the personnel creates a constant sense of resentment in the personnel, decreases their motivation, makes them feel inferior, and undermines their self-confidence:

1: The doctors are more powerful. Last week, one of the personnel told a surgeon that it was not her duty to stich up the patient's skin. The surgeon said she had to do it or leave the OR. In the end, he told her to get out.

The participants also stated that there was injustice in the assignment of break rooms to the staff based on their job positions. The break room of the personnel was too small, while the doctors of different fields had separate rooms which were cleaner, larger and better furnished.

Inefficient management

This category consists of the subcategories of improper management of equipment and unsatisfactory management of the human resources.

Improper management of equipment

Failing to supply standard PPE, not dealing with the shortage of supplies and equipment, allowing timeworn equipment to stay, an unsystematic approach to selecting and purchasing equipment, faults in the quality control of equipment, and negligence in the maintenance of equipment were examples of improper management of equipment:

12: 'Most of our lead aprons are old with broken lead plates. One of the personnel once put his hand on the detector of the C-arm and covered it with an apron, but

unfortunately, the image of his hand was completely visible'.

Lack of masks, face shields, gowns, surgical gloves, disposable lap packs and sleeve covers, lead PPE for x-ray, surgical equipment and cleaning agents for sanitizing the environment and equipment was repeatedly observed in the ORs:

11: 'Sometimes, the housekeepers' gloves get torn, but they just have to keep using them'.

The existence of timeworn equipment, including old operating tables and trolleys, autoclaves, surgical lights and electrocautery and suction machines, also indicated inefficient management of operating room equipment:

17: 'The lifetime of an autoclave is 10 to 15 years. After that, it may explode or burn. In one of the hospitals, an autoclave exploded and killed a person. But here, some of the autoclaves are over 30 years old'.

With regard to an unsystematic approach to selecting and purchasing equipment, the participants mentioned such issues as negligence or tardiness in supplying the necessary equipment and purchasing poor-quality surgical instruments. There were different aspects to the managers' negligence in this area. For example, one of the surgeons stated:

21: 'The lack of equipment and appliances, it's all due to absence of needs assessment and prioritization. I mean, for instance, there are some very expensive machines here which are not very practical, but we are short on cheap instruments which we need for our work every day'.

Another indicator of inefficient management of equipment was shortage of back-up supplies and tardiness in purchasing equipment.

Another problem in the realm of absence of a strategy was appointing inefficient individuals as buying managers. Purchase of poor-quality tools was a result of the appointed sales managers' unfamiliarity with the environment of ORs and purpose of surgical equipment:

5: 'When surgical equipment and supplies are broken, we are constantly quarreling with the storeroom people or the surgeons about the quality of this stuff'.

Examples of faults in the quality control of equipment are non-standard calibration of the instruments and inefficient maintenance of the equipment:

2: 'There are autoclaves here which have failed to pass quality control at any calibration. They can explode. Yet, because of lack of supplies, the hospital cannot put them out of use. They get their technicians to use a new gauge or heat sensor and confirm the autoclaves'.

Because of poor supervision over the maintenance of the equipment, in many cases, the personnel themselves repaired the surgical tools on a trial-and-error basis.

The findings of the study showed that negligence in maintaining the surgical equipment, carelessness in moving the equipment, and leaving the lead safety equipment in the environment were instances of the personnel's negligence in taking care of the equipment:

8: 'Unfortunately, some of the personnel do not follow the principles of handling the aprons. They fold them up, drop them on the ground or, when surgery is over, just leave them on a chair and walk out'.

Unsatisfactory management of human resources

The ineffectiveness of the on-the-job training programs and the personnel's work overload are the consequences of unsatisfactory management of human resources. In the present study, the personnel' basic knowledge about the various aspects of their job was found to be insufficient. The participants' experiences showed that the new personnel were not familiar with the hospital routines and did not know how to use properly the aprons or how to preserve, use and dispose of the chemotherapy drugs. Some of the experienced personnel were not aware that harmful rays could scatter in different directions, regular antibody titer tests were necessary, or electrocautery smoke was dangerous:

7: 'Many of the personnel don't know that their gloves are not 100% impenetrable, so they think they can touch anything as long as they have gloves on'.

In addition, new students' and the personnel's inadequate awareness of the hazards in their job and the safety principles of the equipment results in serious mistakes. The results showed that students are not educated in the safety standards of medical equipment, there are not any training courses in occupational health for surgeons, and new personnel are not trained in using specialized equipment. Moreover, the content of the on-the-job training programs is not comprehensive and practical and there is a lack of educational posters on health standards and occupational safety in ORs. In addition, occasionally, the instructors themselves are inefficient:

6: 'When we first came to the hospital, they gave us some educational booklets called 'log books' We just memorized them for the test. But now, unfortunately, we cannot remember much that can be of use on the job'.

The participants also mentioned that there were problems with the organization of and evaluation in the training programs. For example, announcements were not made properly and the personnel were not required to finish their orientation programs before they could officially start work:

21: 'We work in radiation fields and should have been trained about protection against radiation. Yet, received the training five years after we had started our work'.

Table 1: Demographic characteristics of the participants

Participant	Gender	Age (y)	Marital status	Job position	Work experience (y)	Educational status
P1	Male	41	Married	Perfusionist	18	Master's degree
P2	Male	38	Married	Head nurse	21	Bachelor's degree in nursing
P3	Female	31	Married	Head of Infection control	15	Bachelor's degree in anesthesiology
P4	Female	28	Single	occupational hygiene	4	Bachelor's degree in occupational hygiene
P5	Male	51	Married	Operating room nurse	26	Associate degree in surgical nursing
P6	Female	25	Single	Operating room nurse	1	Bachelor's degree in surgical nursing
P7	Male	25	Single	Operating room instructor	2	Master's degree in surgical nursing
P8	Female	43	Single	Operating room nurse	23	Bachelor's degree in surgical nursing
P9	Female	38	Married	housekeeper	19	High school diploma
P10	Male	36	Married	Medical engineer	4	Master's degree
P11	Male	40	Married	Head of housekeepers	17	Secondary school
P12	Female	25	Single	Operating room radiologist	1.5	Bachelor's degree in radiology
P13	Female	31	Married	central sterile services department personnel	10	Bachelor's degree in surgical nursing
P14	Female	40	Married	Nurse anesthetist	19	Bachelor's degree in anesthesiology
P15	Male	40	Married	Operating room radiologist	17	Bachelor's degree in radiology
P16	Female	25	Single	Operating room nurse	2	Master's degree in surgical nursing
P17	Male	42	Married	Operating room manager	20	Bachelor's degree in anesthesiology
P18	Female	45	Married	Operating room nurse	24	Bachelor's degree in surgical nursing
P19	Female	36	Single	Operating room nurse	17	Bachelor's degree in surgical nursing
P20	Male	43	Married	Anesthesiologist	10	cardiac anesthesiology fellowship
P21	Male	39	Married	vascular surgeon	6	vascular surgery fellowship
P22	Female	39	Married	Head of infection control	16	Bachelor's degree in nursing
P23	Female	38	Married	Head of general affairs	15	Master's degree in psychology
P24	Female	40	Married	Operating room instructor	20	Master's degree in nursing

Table 2: Example of a meaning unit and its condensed meaning units and codes

Meaning Unit	Condensed meaning units	Codes
Very often, there is no extension cord for connecting the surgical devices to the power source, or there are not any distributors around, so we just have to insert the plugs into an outlet in the wall. The outcome is there is a cord in our path and, on many occasions, we have tripped over these cords and almost fallen (p1).	Having to connect surgical devices directly into a power outlet	Shortage of power extension cords or distributors
	The personnel's tripping over the cords of the surgical devices in their paths	Tripping

Table 3: The subcategories, categories and theme extracted from the data

Subcategories	Categories	Theme
Exposure to biological pathogens	Inevitable physical hazards	Working in a context of occupational hazards
Exposure to harmful chemicals		
Risk of ergonomic hazards		
Risk of hazards in the physical environment		
Negligence in using, collecting, and disposing of sharp objects	Disregard for the principles of occupational safety	
Disregard for the principles of sanitizing the surgical environment and instruments		
Disregard for periodic check-ups and on-the-job training		
Failure to use personal protective equipment		
anxiety about complications in patients' conditions	Psychological hazards	
exposure to violence		
Perception of inter-professional discrimination		
Defects in the management of equipment	Inefficient management	
Unsatisfactory management of the human resources		

The personnel's work overload due to lack of workforce and imbalance between tasks and the number of the personnel was another issue under the subcategory of poor management. The outcome is fatigue in the personnel due to inequitable distribution of responsibilities that can lead to their distraction. Distraction can increase the risk of physical injuries for the personnel:

2: 'One of the surgeons who was in the operating room until a late hour last night came back early in the morning. She was run-down and couldn't concentrate and stuck a needle into the hand of one of the assistants'.

4. Discussion

ORs are filled with occupational hazards. [1] The findings of the present study show that the ORP's safety and physical health are threatened by inevitable physical hazards. In addition, psychological hazards, negligence in following the principles of occupational safety, and inefficient management can aggravate the conditions.

Inevitable physical hazards include exposure to biological pathogens and harmful chemicals, ergonomic hazards, and hazards in the physical environment of ORs. Many studies have addressed ORP's exposure to pathogens transmitted by blood and other bodily fluids, [11-13] but one of the main concerns of the participants in the present study was contracting COVID-19. The nature of ORP's job entails frequent contact with asymptomatic patients with COVID-19 or emergency patients in the incubation period of the infection. Since the onset of the COVID-19 pandemic, a large number of ORP have contracted the infection.

According to the findings of the present study, the common causes of needle sticks and injuries by other sharp objects include repeated contact with different kinds of infected sharp instruments, hastiness and agitation in the inexperienced personnel in emergency cases, complexities in large surgical fields, the difficulty

of controlling children during injections, work fatigue, and shortage of PPE, e.g. 3-layer gloves for washing surgical sets. A study in Thailand reports the following as the causes of needle sticks and injuries by other sharp objects: exposure to blood and other bodily fluids, inadequate training, hastiness, inadequate knowledge, outdated instructions, long working hours, failure to use PPE, and lack of personnel. [11] It appears that provision of adequate PPE and hiring a sufficient number of trained personnel can help reduce infection-related hazards in ORs.

Despite the fact that electrosurgical smoke contains pathogenic bacteria and viruses and harmful chemicals which are not filtered by surgical masks, [14] the personnel in the present study did not wear N95 masks and the ORs were not equipped with electrosurgical smoke evacuators. The participants attributed this to their lack of awareness about the dangers of electrosurgical smoke. In a study in England, only three of the 98 observed surgeons used electrosurgical smoke evacuators during surgery. Seventy-two percent of the study population maintained that the precautionary measures to protect the personnel from the potential harms of electrosurgical smoke were not enough. [14] Informing the personnel and managers about the importance and application of safety equipment can help prevent the personnel's exposure to this type of hazards.

The results of the present study and other studies show that exposure to such chemicals as anesthetic gases, high doses of chemotherapy drugs, [15] and formalin and latex, [16, 17] in the ORs is inevitable. Such exposure can result in elevated liver enzymes, reduced lung capacity, hormonal changes and premature menopause in the personnel. Moreover, some ORs equipped with Deco box containers for storing chemical solutions, but in most ORs, there is a shortage of these containers, resulting in the constant exposure of the personnel to the fumes of chemical disinfectants, which had caused allergic contact dermatitis in many of the participants.

In the present study, ergonomic hazards had caused a variety of musculoskeletal disorders (MSDs) in the ORP, including pains in the legs and knees, varicosities, back pain and herniated disks. Similarly, other studies report that unhealthy ergonomic conditions in ORs can lead to work-related musculoskeletal disorders (WRMSDs). [18-20]

The prevalence of these disorders varies between different surgical fields, but they are often severe, adversely affect the personnel's functional abilities, and eventually lead to repeated absenteeism and early retirement. [18-20] The frequent occurrence of WRMSDs shows that there is an urgent need for informing the personnel about the principles of ergonomics to protect them from preventable work hazards. [19] Most of the participants in the present study believed that education in the principles of ergonomics had been neglected which explained the personnel's unfamiliarity with the significance of ergonomics and the high rate of injuries, especially among the surgeons. Accordingly, it is recommended that the ORP should be introduced to the principles of ergonomics in their academic education and on-the-job training programs. Educational posters and boards and the monitors in ORs can be used to ensure the personnel's retention of their learning.

Hazards in the physical environment of ORs can be due to non-standard design of the buildings, low-quality materials, and old age. According to one study, many ORs which are in use today are over 30 y old, and most of them do not have an appropriate design to allow for effective management of equipment and procedures, application of modern technologies, and the personnel's proper performance. [21] Eight of the 24 participants in the present study claimed to have had experience of being tripped or slipped and sustained injuries such as ankle injury and/or severe back pains after falling, all caused by loose wires and tubes on the floor of the ORs. In view of the ever-increasing advances in equipment design and other technologies, ORs must be large environments where the personnel can function at their best and occupational hazards can be avoided.

Even though an operating room should ideally be connected with the main corridor by a sliding door, [22] only a few of the operating room doors in the present study were sliding and the rest were old, wooden pivot doors in which the personnel's hands would sometimes get stuck. Moreover, the few existing sliding doors were made of regular glass, rather than x-ray shielding glass.

Despite many advances in operating room ventilation systems in the world, e.g. the use of airflow patterns like Temperature-controlled Airflow (TAF), [23] there was standard ventilation in only a few ORs in this study, and most centers lacked even the basic infrastructure for ventilation, including standard exhaust vents, exhaust fans and high-efficiency particulate absorbing filters (HEPA filters). Lack of standard ventilation systems in the operating room increases the concentration of not only pathogenic particles in the air, but also anesthetic gases, electrosurgical smoke, and other chemical fumes. [22]

Moreover, because ORs are closed environments, heat from the surgical lights combined with poor ventilation increased the temperature in the observed ORs, and forced the personnel to use regular air conditioners and fans which resulted in further disturbance to the airflow patterns.

Many surgical procedures entail fluoroscopy and ionizing radiation. [24] Over 90% of the absorbed concentrated dose in radiology tests is related to

fluoroscopy. Thus, the personnel who have to be close to fluoroscopy machines absorb considerably large amounts of radiation. [25] In addition, despite the necessity of lead PPE for x-ray, a study in Thailand reports that many hospitals lack essential lead PPE. [26] Therefore, the inadequate proportion of PPE against radiation to the number of personnel and procedures usually forces the personnel to give their PPE to the sterile team and protect themselves by leaving the radiation room and keeping away from the source of radiation.

Regular accurate inspection of the quality of x-ray equipment is a top priority in protection against radiation. [27] However, the participants mentioned that the quality and quantity of their PPE were not controlled on a regular basis. As the risk of cataract in fluoroscopy technicians is significantly high, [28] shortage of lead glasses and occurrence of eye diseases due to frequent exposure to x-ray had forced some of the personnel in the present study to apply for early retirement. Thus, it is essential that operating room radiologists have easy access to adequate functional PPE.

The results of another study show that only 54% of ORP routinely use full radiation protection equipment. [24] According to a study of endourologists, lead glasses and gloves are used by 7.14% and 8.1% of the experts respectively. [29] In the present study, the personnel attributed their reluctance to use PPE to the heavy weight of lead aprons, heat, excessive perspiration, and shortage of equipment.

On the other hand, even though training the operators of radiotherapy equipment is essential, [27] most of the radiologists in the present study had not received much training as there were not many workshops in their field. In addition, some of the personnel did not have film badges and the amount of radiation in many of the centers had not been measured (dosimetry). It appears that lack of training is responsible for the personnel's relative disregard for PPE. Accordingly, it is recommended that hospital managers should take measures to raise radiologists' awareness about the necessity of personal protection against ionizing radiation.

An essential step in guaranteeing hospital personnel's safety in emergencies is providing enough standard exits. [30] However, in a study in Iran, only two of the five observed hospitals had emergency exits. [31] Likewise, most of the ORs in the present study lacked emergency exits and fire alarms; yet, except for a fire safety-training course, the personnel had not received any education in emergency response. Thus, it is recommended that, in addition to improving the qualitative and quantitative structure of emergency exits, hospital managers should designate assembly points and organize emergency drills and exercises.

According to the findings of the present study, some workplace injuries are caused by the personnel's negligence in handling, collecting, and deposing of sharp objects. In one study, 50% of operating room students who were going through clinical training were exposed to sharp and pointed objects. Many of them listed recapping needles as the cause of their injuries. [32]

Even though the process of washing and disinfecting surgical sets must be performed according to predefined standards, [33] the participants' experiences showed that, occasionally, because of lack of personnel and work overload, the instruments which were not visibly contaminated were not washed and were directly packaged and put inside autoclaves.

Despite the significance of workshops and the authorities' recommendations, the ORP ignored their periodic check-ups and on-the-job training programs. Also, the personnel at the Sterile Processing Department (CSSD) who are exposed to a variety of occupational hazards are required to use appropriate PPE. [33] Yet, it was repeatedly observed that the personnel of this unit did not wear aprons, boots or safety glasses when washing the sets. A study in Ethiopia shows that only 12% of the personnel at medical centers completely follow safety standards. [34] These findings indicate the personnel's poor compliance with safety standards. It is recommended that hospital managers raise the personnel's awareness about the necessity of using safety equipment and have operating room managers regularly monitor and evaluate the personnel's use of this equipment.

The ORP's health was also threatened by various psychological hazards. One study reports that 62.2% of ORP are exposed to high levels of stress, with psycho-emotional and environmental factors being their most noticeable stressors. [35] Frequent exposure to high levels of stress can result in emotional exhaustion and depersonalization. [36] Similarly, the findings of the present study showed that the stress caused by seeing patients in critical conditions and other distressful scenes made the personnel feel upset for long periods. These factors can lead to occupational burnout as a psychological syndrome. [37]

The findings of the present study also showed that the ORP in Iran experience different forms of violence. In a study in China, 92.1% of the 1557 operating room nurses were found to have experienced workplace psychological violence (WPV). [38] Psychological violence refers to non-physically hostile, intimidating, demeaning, or offensive interpersonal behavior which is essentially psychological and can have negative psychological and behavioral effects on the victims.[39]

Studies have also shown that there is a significant positive relationship between job burnout and workplace

violence perceived by doctors in emergency departments [40] and between verbal abuse and job burnout in nurses. [41] Certain situations which occur because of poor coordination between the members of the surgical team during surgeries can cause conflict and adversely affect their cooperation. [42] In the present study, despite the efforts of the personnel to improve teamwork in the operating room, acts of violence during surgeries occurred for a variety of reasons, including fatigue, disregard for regulations, dominance of a hierarchical structure, inexperience, and a poor understanding of each other's responsibilities. Tension during surgeries, failure to prepare surgical requirements before surgery, negligence in performing duties, surgeons' distrust of the personnel, and lack of support for the new personnel during complex operations were other causes of verbal abuse in the ORs.

Senior managers' indifference to the personnel and bullying were other instances of violence against the personnel in the present study. In a review study, 22 of the 32 reviewed articles reported prevalent acts of bullying which contribute to burnout and disrespect during surgeries. [43] The participants' experiences showed that occurrence of violence during surgeries can be a main cause of inability to concentrate and, consequently, aggravation of occupational hazards. Distraction can diminish individual and team efficiency in operating room [44] and is a major contributing factor in 50% of medical error. [45] Workplace violence can seriously threaten individuals' mental health, reduce job satisfaction, and create suicidal thoughts. [43] In the present study, the ORP's perception of bullying had led to lack of motivation, apathy, psychosomatic pains, and reduced job satisfaction. In today's civilized world, equitable treatment of the personnel and attention to organizational justice should be at the core of working in a social system, but a study reports that perception and experiences of discrimination is the main concern of nurses in Iran. [46] The results of the observations and interviews also showed that the personnel frequently perceived inter-professional discrimination. Measures should be taken to prevent problems related to coordination and performance of duties, hierarchy, rank differences and superiority from affecting team interactions. Conflict-management training can help surgeons express their dissatisfaction and criticism firmly, but politely.

ORs are known as interdisciplinary departments where the number of surgical instruments, following technological advances, is increasing. Ensuring the correct operation of surgical equipment is essential to the success of surgeries. [47] However, the findings of the present study showed defects in the management of equipment in the ORs.

Systematic maintenance is an essential step in the lifetime of a device. [48] In the present study, defects in the equipment maintenance plans, non-standard calibration of the equipment, and inefficient maintenance of the equipment were observed. Senior managers did not monitor the equipment maintenance procedures or the companies did not undertake the repairs or maintenance of their products because their useful lifespan was over.

Human resources are known to be the most valuable asset of every organization. Today, most experts believe that the success of an organization depends on the success of its human resources. [49] Development of human resources can improve the personnel's behaviors, create learning opportunities for them, and develop their skills and performance. [50] In the present study, despite in-service classes related to infection control and operating devices such as DC shock, electrocautery, and C-Arm machines, there were defects in different aspects of the on-the-job training programs: the personnel's professional knowledge was unsatisfactory, the educational content was not comprehensive and practical, and the training courses were not properly announced, organized or evaluated. It is recommended that healthcare managers stress the importance of organizing and evaluating training programs at all levels to improve the personnel's skills and performance.

The personnel's work overload was another indicator of poor human resource management in the present study. Other studies list shortage of nurses and auxiliary staff as the cause of work overload. Moreover, circulating nurses attribute the increase in their workload to damaged appliances and shortage of equipment, blood and drugs and scrub nurses refer to complexities in certain surgeries as the culprit. [51] In the present study, shortage of workforce was more noticeable when some of the personnel were on sick leave. On the other hand, some of the ORPs may neglect their responsibilities or impose their duties on the others, especially the newer ones.

The extra workload leads to musculoskeletal pains, disorders, and fatigue in the personnel. Fatigue, in turn, can lead to distraction and increase the risk of physical injuries. Work overload also has adverse effects on job satisfaction, motivation and inter-personal interactions and threatens the personal safety. [51] Maintaining a balance between workload and the number of personnel and effective management of task distribution by managers can help reduce the personnel's workload and the consequences of excessive pressure.

5. Conclusion

The results of the present study show that there are a variety of physical and psychological risk factors in the context of operating rooms that can threaten the occupational safety and health of all the doctors and

nurses working there. Such factors as the personnel negligence and the managers' inefficient management of equipment and human resources can make the situation worse. To safeguard personnel health and safety, healthcare administrators and policy-makers must ensure adequate supply of surgical devices, equipment and PPE's and make the physical environment of operating rooms safe and standardized. The element of neglect in complying with safety standards needs to be dealt with strict measures. The stress and staff conflict lead to psychological hazards, and need efficient management and plan Continuing on-the-job training programs and occupational safety and health workshops should be organized.

6. Conflicts of interest

The authors declare that there was no conflict of interest regarding the publication of this article.

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8. Authors' contribution

MAD: Study design and concept, performed the study

CT: Concept, drafting, literature search

ZK: Data collection. Analysis.

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