Society of Medical Education & Research

2021, Volume 1, Issue 1, Page No: 58-65

International Journal of Social and Psychological Aspects of Healthcare

Assessment of Operating Room Workers' Exposure to Surgical Smoke and Their Well-Being During the COVID-19 Pandemic

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Abstract

This study aimed to assess the perceptions of operating room workers regarding surgical smoke exposure and their personal well-being levels during the COVID-19 pandemic. Conducted as a descriptive study between May and June 2022, the research included 82 operating room staff members from a public hospital in Istanbul. Data were collected using a questionnaire covering sociodemographic details, surgical smoke exposure, and the personal well-being scale. Descriptive statistical methods were used to analyze the data. Among the participants, 89% believed that they had been exposed to surgical smoke. Symptoms reported among those exposed included headaches (45.1%), coughing (11%), throat irritation (31.7%), eye discomfort (56.1%), excessive tearing (34.1%), and respiratory issues (20.7%). To minimize exposure, staff relied on protective measures such as surgical masks (74.4%), aspiration catheters (59.8%), gowns (74.4%), goggles (74.4%), filters (35.4%), and filtration masks (6.1%). In addition, 93.9% expressed a desire for training on surgical smoke. The mean score on the personal well-being scale was $\bar{X} = 41.76$, indicating low well-being. The findings suggest that preventive measures in operating rooms were inadequate during the pandemic, leading to various health symptoms among staff and reduced well-being. More efforts are needed to control and eliminate surgical smoke in operating rooms. It is necessary to investigate cost-effective smoke extraction methods and investigate the long-term effects of chronic exposure among healthcare personnel.

Keywords: Surgical smoke, COVID-19, Operating room, Pandemic

Introduction

Operating rooms incorporate state-of-the-art technology and a range of surgical techniques, requiring a collaborative effort among medical teams. Despite these advancements, the rapid nature of procedures and the reliance on various medical instruments introduce potential health risks to both patients and staff [1-3]. Among these hazards is surgical smoke [3, 4]. This byproduct, also referred to as cautery smoke, plume, aerosol, bioaerosol, or surgical air smoke, originates from energy-based surgical tools such as electrocautery devices, lasers, ultrasonic instruments, and high-speed drills. The intense heat generated by these instruments leads to the thermal decomposition of proteins and organic matter, resulting in the emission of smoke containing various substances [1, 2, 5, 6]. While the majority of surgical smoke—approximately 95%—is composed of water vapor, the remaining 5% consists of cellular debris, blood particles, viruses, bacteria, and toxic gases [6-10]. Research has shown that microorganisms present in surgical smoke can remain viable for up to 72 hours and may disperse over a meter from the surgical field depending on particle size [9, 11]. Known for its mutagenic and carcinogenic properties, surgical smoke emits an unpleasant odor and poses serious health concerns for both patients and operating room personnel [1, 3, 7]. Prolonged exposure to these airborne contaminants has been linked to multiple health

Access this article online

Website: https://smerpub.com/ **E-ISSN: 3108-4818**

Received: 25 May 2021; **Revised:** 17 September 2021; **Accepted:** 18 September 2021

How to cite this article: Cinar F, Sanlier NB. Assessment of Operating Room Workers' Exposure to Surgical Smoke and Their Well-Being During the COVID-19 Pandemic. Int J Soc Psychol Asp Healthc. 2021;1:58-65. https://doi.org/10.51847/YI0tjoClOT

conditions among surgical staff, including headaches, dizziness, nausea, vomiting, respiratory difficulties, throat irritation, coughing, sneezing, eye discomfort, hypoxia, airway inflammation, fatigue, conjunctivitis, dermatitis, muscle pain, cramps, anemia, rhinitis, asthma, anxiety, and hepatitis [2, 3, 9, 11].

The outbreak of coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has significantly impacted global healthcare systems. SARS-CoV-2 primarily spreads via respiratory droplets exceeding 5 μm, which are expelled through actions such as coughing and sneezing [12-16], though the potential for aerosol-based transmission through smaller particles (less than 5 μm) remains a concern [17]. The presence of the virus has been detected not only in respiratory secretions but also in the gastrointestinal system, blood, and peritoneal fluid of infected individuals [18, 19]. Consequently, surgical procedures involving COVID-19 patients may generate infectious smoke, increasing the risk of exposure for operating room staff [19]. While there is no conclusive proof that SARS-CoV-2 can be transmitted through surgical smoke, the possibility has not been entirely ruled out [20]. Despite longstanding evidence highlighting the risks associated with surgical smoke exposure, many perioperative healthcare workers remain unaware of its harmful effects or fail to comply with recommended evacuation measures [7, 21]. The psychological and physical toll of the pandemic has further impacted healthcare workers, including nurses. Personal well-being encompasses an individual's perception of their life, emotional reactions, environmental satisfaction, and overall quality of life assessment [22]. Given the direct contact healthcare providers have had with COVID-19 patients and the ongoing uncertainty surrounding infection risks, there is limited research assessing their well-being during this period.

This study aimed to assess the perspectives and personal well-being of doctors, nurses, and health technicians working in an operating room setting regarding their exposure to surgical smoke during the COVID-19 pandemic.

Materials and Methods

This descriptive study was conducted in a public hospital in Istanbul between November 2021 and January 2022. The research focused on operating room personnel, including doctors, nurses, and health technicians. Rather than encompassing the entire population, a selected sample of healthcare professionals participated. The hospital's operating room employed a total of 102 staff members, consisting of 38 doctors, 45 nurses, and 19 health technicians. However, after obtaining the necessary research permissions, 82 individuals who consented to participate completed the study.

Data collection

A structured questionnaire was used to gather information on surgical smoke exposure, associated risks, symptoms, and protective measures, following established literature [5, 9, 22]. The questionnaire included sections on participants' demographic details (such as age, gender, profession, education level, years of experience, and type of operating room), their awareness of surgical smoke, symptoms experienced due to exposure, and preventive actions taken.

Personal well-being index-adult (KIOI-Y)

The Personal Well-Being Index-Adult (KIOI-Y), developed by the International Wellbeing Group, is a widely recognized tool in positive psychology. The psychometric properties of the Turkish adaptation were validated by Meral [22] in an adult sample. This scale is an 11-point Likert-type measurement tool (0–10), designed to assess subjective well-being based on satisfaction levels across eight life domains. Scores range from 0 (not satisfied at all) to 80 (highest level of satisfaction), with higher scores indicating greater perceived well-being. Participants completed the data collection forms in approximately 5–7 minutes.

Ethical considerations

Approval for the study was obtained from the Scientific Research Ethics Committee of a Nearby Foundation University (Date: 22.08.2022, Decision: 2022/34), along with written permission from relevant institutions and healthcare staff.

Data analysis

The collected data were analyzed using the Statistical Package for Social Sciences (SPSS) version 25.0 software. Descriptive statistics, including mean values, percentages, and frequency distributions, were calculated. The independent samples t-test was employed for further statistical analysis.

Results and Discussion

The study included healthcare workers with an average age of 37.01 ± 15.21 years. Among the participants, 67.1% were female, 50% were nurses, and 62.2% had a graduate-level education. Additionally, 52.2% had been working in the operating room for 16 years or more **(Table 1)**.

Table 1. The health of its employee's introductory properties (n = 82)

Feature	Variable	Number (n)	%
Gender	Woman	24	35.8
	Male	43	64.2
Age (years)	20-30	15	18.3
	31-40	35	42.7
	41-50	28	34.1
	≥ 51	4	4.9
Job	Doctor	23	37.3
	Nurse	41	31.3
	Health technician	18	31.3
Education Status	High School - Associate license	6	7.3
	License	25	30.5
	Graduate	51	62.2
In the operating room Study year	0-5 years	18	22
	6-10 years	8	9.8
	10-15 years	18	22
	≥ 16 years	38	46.3
Total		82	100

The distribution of healthcare professionals' perspectives on surgical smoke during the COVID-19 pandemic is presented in **Table 2**. A significant 64.6% of the participants were aware of surgical smoke exposure during surgeries, but 91.5% reported that they had not received any formal training or information regarding surgical smoke. Furthermore, 89% of the respondents believed they had been exposed to surgical smoke. Regarding protection measures, 70.7% of healthcare workers felt they had taken steps to protect themselves, but 31.7% considered these measures insufficient. Additionally, 37.2% of participants indicated that no smoke evacuation equipment was available in operating rooms during the pandemic, and 58.5% stated that no extra precautions were implemented during this period. 43.9% were uncertain about the existence of any protocols for handling surgical smoke at their hospital. A substantial 79.3% of healthcare workers reported receiving no training on surgical smoke in their institution, and 93.9% confirmed they had not received any training on the topic. **Table 3** highlights the signs and symptoms reported by healthcare workers exposed to surgical smoke, including headaches (45.1%), cough (11%), throat burning (31.7%), eye irritation (56.1%), tearing (34.1%), and respiratory issues (20.7%).

Table 2. The health of its employees surgical into the smoke-oriented opinions (n = 82)

Opinions		Number (n)	%
Do you have information about surgical smoke during the COVID-19 Pandemic?	Yes	53	64.6
	Sure I am not	3	3.7
	No	26	31.7
Have you received education on surgical smoke during the COVID-19 Pandemic?	Yes	7	8.5
	No	75	91.5
Have you read any scientific articles about surgical smoke during the COVID-19 Pandemic?	Yes	24	29.3
	No	58	70.7

Do you think you are exposed to surgical smoke during the COVID-19 Pandemic?	Yes	73	89
	No	9	11
How often are you exposed to surgical smoke during the COVID-19 Pandemic?	No time	9	11
	Sometimes	28	34.2
	Stylish stylish	45	54.8
Do you take protective measures against surgical smoke during the COVID-19 Pandemic?	Yes	58	70.7
	No	24	29.3
Do you think the measures you took to protect yourself from surgical smoke are sufficient during the COVID-19 Pandemic?	Yes	25	30.5
	Sure I am not	31	37.8
	No	26	31.7
Is there a smoke evacuation device in the operating room during the COVID-19 Pandemic?	Yes	15	18.3
	Sure I am not	22	26.8
	No	45	54.9
Is there a smoke evacuation protocol in the hospital during the COVID-19 Pandemic?	Yes	17	20.7
	Sure I am not	36	43.9
	No	29	35.4
Have you received education on surgical smoke in the hospital during the COVID-19 Pandemic?	Yes	13	15.9
	Sure I am not	4	4.9
	No	65	79.3
Have you received any education on surgical smoke?	Yes	77	93.9
	No	15	6.1

Based on the analysis of the research data, the overall score for the personal well-being index among healthcare professionals was found to be $\bar{X} = 41.76 \pm 5.60$, indicating a low level of well-being. The satisfaction level was reported as 7.12 ± 1 **(Table 3)**.

Table 3. Signs and symptoms of healthcare workers exposed to surgical smoke (n = 82)

Symptom and Results	Number (n)	%
Top pain	37	45.1
Nausea	12	14.6
In the throat combustion	26	31.7
Cough	9	11
Eyelash irritation	46	56.1
Eyelash to live	28	34.1
Respiratory problems	17	20.7
Sneeze	2	2.4
Irritability	10	12.2
Top turning	11	16.4
Vomiting	11	16.4
Weather way inflammation	12	14.6
Weakness	9	11
Hypoxia	2	2.4
Conjunctivitis	10	12.2
Rhinitis	10	12.2

Asthma	10	12.2
Your wife pain	2	2.4
Anemia	2	2.4
Nasopharyngeal lesion	2	2.4
Dermatitis	3	3.6

* Suddenly, more choices marked

Healthcare workers reported using surgical masks (74.4%), aspiration catheters (59.8%), gowns (74.4%), goggles (74.4%), filters (23.2%), and filtration masks (6.1%) for protection, with 93.9% expressing a desire for education on surgical smoke **(Table 4)**.

Table 4. Protection of healthcare workers from surgical smoke oriented they received measures (n = 67)

Measures	Number	%
Surgical mask	61	74.4
Aspiration catheter	49	59.8
Apron	61	74.4
Glasses	61	74.4
Filter	19	23.2
Filtration mask	5	6.1

*Suddenly, more choices marked

Table 5. Personal well-being scale mean scores, internal consistency coefficients (n = 82)

Personal well-being index items			
	$\bar{X}$	SD	Cronbach Alpha
Satisfaction with living conditions	2.79	1.51	
Satisfaction with health status	5.68	2.01	
Satisfaction with life achievements	7.41	1.30	
Satisfaction with relationships with others	7.12	1.16	
Sense of safety	2.79	1.51	.78
Satisfaction with societal relationships and belonging	4.42	1.26	
Confidence in future	4.42	1.26	
Satisfaction with spiritual life (e.g., religious, spiritual life)	7.09	1.00	
Total personal well-being scale score	41.76	5.60	

$P < 0.05$

The analysis revealed no significant statistical correlation between healthcare workers' well-being scores and factors such as exposure to surgical smoke during the pandemic, the actions taken to prevent exposure, the perceived effectiveness of those actions, or the availability of smoke evacuation devices in the operating rooms ($P > 0.05$) **(Table 5)**.

Concerns over the presence of live microorganisms in surgical smoke, and their potential to contaminate surgical staff, were highlighted in several studies dating back to the 1980s. These microorganisms include viruses, fungi, bacteria, and body cells, with a particular focus on viable tumor cells. The COVID-19 pandemic reignited these concerns due to the potential risk of transmitting the COVID-19 virus during procedures using coagulation devices. However, no reports have confirmed the presence of the COVID-19 virus in surgical smoke, and the risk of transmission, if any, remains unclear [23].

As new technologies have been introduced, the risk of exposure to surgical smoke in operating rooms has increased [8, 10, 21]. Research indicates that current operating room ventilation systems and the use of surgical masks are not sufficient to prevent exposure to

surgical smoke [24, 25]. While the long-term health effects of surgical smoke exposure remain unclear, evidence suggests that operating room personnel face a greater risk of work-related illnesses due to the harmful substances found in surgical smoke compared to other workers [4, 26].

In our study, operating room staff—comprising doctors, nurses, and technicians—reported experiencing various symptoms associated with surgical smoke. These included headaches (45.1%), coughing (11%), throat irritation (31.7%), eye irritation (56.1%), tearing (34.1%), and respiratory issues (20.7%). These findings align with previous studies [14, 15, 24, 26, 27], reinforcing the idea that healthcare workers are likely to suffer from at least one symptom due to surgical smoke exposure.

Approximately 70.7% of healthcare workers took measures to protect themselves from surgical smoke, but 31.7% felt those measures were inadequate. Additionally, 37.2% of respondents indicated that there was no smoke evacuation equipment available in the operating rooms during the COVID-19 pandemic, and 58.5% noted that no extra precautions were implemented during this time. Furthermore, 43.9% were unsure if any formal protocol existed for managing surgical smoke at their hospital. A large percentage (79.3%) had not received any training on surgical smoke management, and 93.9% expressed an interest in receiving such training. This aligns with recommendations in the literature to reduce exposure to surgical smoke by using effective smoke evacuation systems, taking appropriate preventive measures, and offering training to operating room staff [6, 28].

The study also found that personal protective equipment (PPE) such as surgical masks (74.4%), aspiration catheters (59.8%), gowns (74.4%), and goggles (74.4%) were provided to staff, though fewer received filters (23.2%) or filtration masks (6.1%). Additionally, 93.9% of workers expressed a desire to receive training on surgical smoke. Although protective measures were taken, there was uncertainty about their adequacy. Research suggests that PPE such as masks, gowns, and goggles is crucial for protecting staff from surgical smoke [4, 6, 29]. Studies have shown similar usage of protective gear among staff for shielding against surgical smoke [2, 5, 21]. Surgical masks are commonly used to guard against microorganisms and bodily fluids during procedures, but they are ineffective in filtering surgical smoke particles, which are smaller than 0.1 µm. To address this, high-filtration masks are recommended to block these smaller particles and protect against airborne infectious agents [1, 27, 30]. Furthermore, the ventilation systems in operating rooms are inadequate in preventing the adverse effects of surgical smoke. Therefore, high-filtration masks, smoke evacuation systems, and additional protective gear, such as goggles and gowns, are strongly recommended for the surgical team [6, 21].

Conclusion

Surgical smoke poses a serious threat to the safety of personnel in operating rooms, creating a dangerous working environment. It is essential to raise awareness about the risks associated with surgical smoke to ensure proper protection. Both healthcare professionals in the operating room and the institutions they work for must be aware of the necessary precautions. To address this, it is suggested that institutions organize training sessions on smoke protection, implement smoke evacuation systems, create detailed protocols, and establish written guidelines. Institutions should also promote the proper use of protective gear and ensure these practices are reinforced through continuous training.

Acknowledgments: We acknowledge the researchers who contributed to this research.

Conflict of Interest: None

Financial Support: None

Ethics Statement: The study received approval from the Scientific Research Ethics Committee of a foundation university (Date: 22.08.2022, Decision: 2022/34). Written consent was obtained from both the administrative units and healthcare workers at the hospital where the study was conducted.

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