Cogitare Enfermagem

ORIGINAL ARTICLE

Protective measures adopted by the intraoperative team in occupational exposure to surgical smoke: ocular signs and symptoms*

HIGHLIGHTS

1. Photophobia showed a p-value of 0.04 among users of protective eyewear.
2. No significant association between protection and intensity.
3. Strengthen cohesive information on the use and adherence to PPE.
4. Information to reduce occupational risks from smoke exposure.

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ABSTRACT

Objective: To analyze the association between the intensity of ocular signs and symptoms presented by intraoperative team workers exposed to surgical smoke and the protective measures adopted. **Method:** A quantitative, analytical cross-sectional study was conducted between August and September 2021 in operating rooms at an oncology hospital and a university hospital. Three instruments were used: sociodemographic and occupational characterization, a scale to assess the intensity of signs and symptoms related to exposure to surgical smoke, and an assessment of the use of protective measures by workers exposed to surgical smoke. The Chi-square test and Pearson's correlation test were used to analyze the data. **Results:** There was a significant association between photophobia and the use of protective eyewear (p=0.04). **Conclusion:** The use of protective eyewear showed statistical significance regarding photophobia. However, no significant association was observed between the other protective measures and the intensity of ocular signs and symptoms.

DESCRIPTORS: Occupational Risks; Eye Health; Electrosurgery; Signs and Symptoms; Photophobia.

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INTRODUCTION

The Surgical Center (SC) is a hospital unit intended for the execution of anesthetic-surgical, diagnostic, and therapeutic procedures, both in elective and emergency situations. The unique dynamics of the SC, characterized by high technological density and a diversity of situations, demand specialized skills in the provision of health care[1].

Given this, electrocautery equipment is widely used in surgery and is intended to cut tissue and coagulate blood vessels, producing, as a by-product, surgical smoke dispersed in the unhealthy environment[2].

The active electrode of the electrocautery, upon contact with human skin, generates heat in the tissues, resulting in the rupture of cell membranes. This process releases surgical smoke into the environment, composed mainly of water vapor (95%) and, to a lesser extent (5%), of cellular debris, biological byproducts such as viruses and bacteria, as well as various chemical compounds[3-4].

The particles of chemical compounds present in surgical smoke varied according to the type of incision and the tissue manipulated.[5] In electrocoagulation, particles with an average aerodynamic size of 0.07µm are formed, while in laser tissue ablation, these particles are larger, around 0.31µm.[6]

Among the chemical compounds present in surgical smoke are: toluene, xylene, ethylbenzene, butyl acetate, acrylonitrile, 1,2-dichloroethane, phenol, chlorine, cyanide, hydrogen cyanide, carbon monoxide, and Polycyclic Aromatic Hydrocarbons (PAHs). Naphthalene is one example of a PAH, being considered carcinogenic to those exposed.[2,7]

Workers exposed to surgical smoke may experience signs and symptoms such as headache, dizziness, nausea, and those related to the ocular system: ocular hyperemia, tearing, eyelid swelling, gritty sensation, eye discharge, itching, light sensitivity, blurred vision, and burning eyes.[8]

To prevent occupational exposure to surgical smoke through inhalation, organizations such as the National Institute for Occupational Safety and Health (NIOSH) and the Association of Perioperative Registered Nurses (AORN) recommend the use of Personal Protective Equipment (PPE), such as the use of N95 respirators and local surgical smoke evacuators.[9-10]

Normally, surgical masks are used in surgical services, which, in addition to not sealing the face properly due to loose stitches, provide protection against droplets with large particles: sprays or splashes larger than 0.9 µm, which do not make them safe for effective protection against surgical smoke inhalation.[11] The N95 respirator, recommended by NIOSH and AORN, is capable of filtering particles smaller than 0.3µm, providing greater protection against surgical smoke when compared to a common surgical mask[12].

According to Regulatory Standard No. 6, eye and face protection equipment is essential in situations where there is a significant risk of particle projection, such as in equipment operation activities in lumber mills, sawmills, pesticide application, beekeeping, sandblasting, as well as in environments with chemical and biological risks.[13]

Facial protection is also fundamental, and the use of PPE is recommended in environments with potential risks to the worker. Face shields are designed to safeguard the face and neck against impacts from particles and splashes of harmful liquids, providing protection against glare and radiant heat.[13]

Furthermore, surgical smoke evacuation systems filter out particles larger than 0.12µm present in the environment, preventing the inhalation of large particles by exposed workers, but this type of protection does not guarantee safety, as it is known that smaller particles can be produced.[5]

Despite numerous studies on the effects of surgical smoke on the respiratory system and on biological and chemical risks, investigations addressing its impacts on the ocular system are limited. Signs such as hyperemia, tearing, burning, photophobia, eyelid edema, a gritty feeling in the eye, eye discharge, itchy eyes, and night blindness are often underexplored, and there is a scarcity of evidence linking these manifestations to the use of eye and face protection in the surgical environment.

The relevance of this study lies in the lack of evidence on the effectiveness of ocular PPE against surgical smoke, despite the recommendations of NR-6 and international standards. Such guidelines are still rarely applied in this context, and there is no consensus on their relationship with the prevention of ocular symptoms. This investigation seeks to fill this gap, contributing to the improvement of protocols and safe practices in the SC.

To this end, this study aims to answer the following gap in knowledge about occupational exposure to surgical smoke: are the ocular signs and symptoms presented by workers exposed to surgical smoke related to the use of protective measures adopted in the workplace?

Therefore, this study aimed to analyze the association between the intensity of ocular signs and symptoms presented by intraoperative team workers exposed to surgical smoke and the protective measures adopted.

METHOD

This is a quantitative cross-sectional analytical study[14]. Cross-sectional analytical studies, in particular, investigate the exposure-disease relationship in a population at a specific time, offering a snapshot of the situation. These studies assess the relationship between diseases and other variables of interest present in a defined population, with exposure and outcome measured simultaneously[15].

For the research to have methodological rigor, the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) initiative were followed, which is composed of the information that must be present in the following items of the study: title, abstract, introduction, methodology, results, and discussion of the results found through the existing literature on the subject[16].

Data collection was carried out between August and September 2021 at two institutions located in Northern Paraná: Institution I is a philanthropic oncology referral service, represented by six operating rooms, attending elective, urgent, and emergency surgeries to patients covered by the Unified Health System (*Sistema Único de Saúde* - SUS) and other agreements. The medical and nursing team consists of 115 employees, including 52 nursing technicians, 50 surgeons, four nurses, and nine residents in oncological surgery.

Institution II is a high-complexity university hospital, responsible for performing an average of 826 surgical procedures per month, with seven operating rooms operating 24 hours a day, composed of 258 workers on the intraoperative team, including

postgraduate students in the health area, namely: 108 doctors, 92 medical residents, 40 nursing technicians, and 18 nurses.

The selection of participants followed specific criteria. Intraoperative team workers and postgraduate students in the health field exposed to surgical smoke, belonging to the medical and nursing teams, were included. Exclusion criteria included undergraduate students, surgical instrument technicians from private companies, as well as employees from the hygiene and pharmacy areas, due to differences in their work processes and levels of exposure compared to nursing professionals.

By using non-probabilistic convenience sampling, 343 intraoperative team workers and postgraduate students in the health field were eligible for this study, resulting in the exclusion of 15 workers from Institution I, with four refusals and 11 being on leave for vacation or external internships. At Institution II, 15 exclusions were recorded, with eight refusals, two private surgical instrument technicians, and five being on leave for vacation or other absences.

The approach to the workers occurred individually, at their workplace, where the research and its objectives were presented. The Free Informed Consent Term (FICT) was made available to eligible respondents interested in participating so that they could sign it. Additionally, essential guidelines were provided for the correct completion of the data collection instruments used in this study.

Three instruments were used: sociodemographic and occupational characterization of the worker, the Scale for Assessing the Intensity of Signs and Symptoms Related to Exposure to Surgical Smoke (*Escala para Avaliação da intensidade dos Sinais e Sintomas relacionados à Exposição à Fumaça Cirúrgica* - EASE), and assessment of the use of protective measures by workers exposed to surgical smoke. The sociodemographic and occupational characterization instrument presents age and time in the area of activity as numerical variables; profession and education as ordinal variables; and sex and protective measures as nominal variables.

The EASE is composed of 33 items, subdivided into six domains: respiratory system (10 items), ocular system (9 items), digestive system (3 items), musculoskeletal system (2 items), integumentary system (4 items), and nervous system (5 items). The scale is measured numerically, ranging from 0 to 3, where 0 (no signs and symptoms), 1 (low intensity), 2 (moderate intensity), and 3 (high intensity), corresponding to the signs and symptoms assessed. This scale was validated in terms of content, appearance, and relevance by experts in SC and in scale development and validation, with a Content Validity Index above 0.9 (90%)[17]. A pilot test was conducted with 20 intraoperative team professionals exposed to surgical smoke. The participants, representing the study's target audience, adequately understood the items and the scale, and no modifications to the instrument were necessary.

This study corresponds to a specific analysis of a broader research project entitled "Assessment of the intensity of signs and symptoms related to occupational exposure to surgical smoke: analysis of psychometric properties of a scale and protective measures for workers." This analysis addressed the domain related to the ocular system, composed of nine items: ocular hyperemia, eyelid edema, sensation of sand in the eyes, ocular discharge, ocular pruritus, photophobia, hemeralopia, and ocular burning.

After the health professional completed the self-assessment, the scale generated a global score; that is, the higher the score in the domains, the greater the intensity of exposure to surgical smoke. The instrument used to assess the protective measures adopted in the work environment was structured in a dichotomous manner. Workers

provided responses indicating whether or not they used different protective measures, such as surgical masks, N95 respirators, protective eyewear, and surgical smoke aspirators, during exposure to this smoke.

The analysis and organization of quantitative data were carried out using Microsoft Excel® spreadsheets and subsequently subjected to statistical analysis using Jamovi software (version 0.9, 2018).

In the descriptive analysis, measures of central tendency (means) were used for continuous variables, and relative frequency (%) and absolute frequency (n) for categorical variables (sex, education level, profession, work shift, and protective measures).

The Chi-square test and Pearson's correlation test were used for comparisons between proportions, as well as for the analysis of associations between variables (signs and symptoms and protective measures). The level of statistical significance adopted was 5% for all analyses.

The research project was approved by the Permanent Ethics Committee for Research with Human Beings of one of the institutions where the research was conducted, with opinion number 4,693,774, in accordance with Resolution 466/12.

RESULTS

The study population included 373 healthcare professionals, of whom 12 were excluded due to refusals and three were on leave during the data collection period, totaling 30 exclusions. Thus, the final sample consisted of 343 workers, with 100 (29.15%) from Institution I and 243 (70.85%) from Institution II. The average age of the participants was 37 years, with an average length of service in the SC of seven years. The prevalence was male (n=173; 50.43%), physicians (n=144; 41.98%), medical residents (n=89; 25.94%), nurses (n=26; 7.28%), and nursing technicians (n=84; 24.48%), specialists (n=150; 43.73%), masters (n=21; 6.12%), and doctors (n=16; 4.66%), with full-time work shifts (n=218; 63.55%), morning shifts (n=62; 18.07%), afternoon shifts (n=51; 14.86%), and night shifts (n=16; 4,66%).

Table 1, which represents the association between the intensity of signs and symptoms related to the ocular system of workers exposed to surgical smoke and the protective measures adopted in the services participating in the research, indicates that there was no association (p-value ≤ 0.05) between the variables intensity of ocular signs and symptoms and the use of protective measures.

Table 1. Association between the intensity of ocular signs and symptoms related to exposure of workers exposed to surgical smoke and the protective measures adopted in institutions I and II. Londrina, PR, Brazil, 2025

(continue)

Protective measures	Intensity of ocular signs and symptoms				
	Use	Low (n/%)	Moderate (n/%)	High (n/%)	p-value*
Surgical Mask	Yes	309 (90.10%)	11 (3.20%)	0	0.93
	No	21 (6.10%)	1 (0.30%)	0	
N95 Respirator	Yes	128 (58.90%)	7 (2.00%)	1 (0.30%)	0.18
	No	202 (58.90%)	5 (1.50%)	0	
Protective Eyewear	Yes	161 (46.90%)	8 (2.3%)	1 (0.30%)	0.28
	No	169 (49.30%)	4 (1.20%)	0	

Table 1. Association between the intensity of ocular signs and symptoms related to exposure of workers exposed to surgical smoke and the protective measures adopted in institutions I and II. Londrina, PR, Brazil, 2025

(conclusion)

Protective measures	Intensity of ocular signs and symptoms				
	Use	Low (n/%)	Moderate (n/%)	High (n/%)	p-value*
Surgical Smoke Extractor	Yes	9 (2.60%)	0	0	0.83
	No	321 (93.60%)	12 (3.60%)	1 (0.30%)	

Caption: *Chi-square test $p < 0.05$.

Source: Prepared by the authors (2025).

Conversely, the analysis presented in Table 2 identified an association between the intensity of the photophobia signal related to the ocular system, with a p-value of 0.04 in workers exposed to surgical smoke, and the use of goggles as a protective measure.

Table 2. Association between the intensity of signs and symptoms related to the ocular system of workers exposed to surgical smoke and the use of protective eyewear adopted in institutions I and II. Londrina, PR, Brazil, 2025

Signs and symptoms	Protective eyewear	No signs and symptoms (n/%)	Low intensity (n/%)	Moderate intensity (n/%)	High intensity (n/%)	p-value
Eye hyperemia	Yes	136 (39.70%)	29 (8.50%)	5 (1.50%)	0	0.09
	No	146 (42.60%)	20 (5.80%)	3 (0.90%)	4 (1.20%)	
Tearing	Yes	117 (34.10%)	44 (12.50%)	8 (2.30%)	1 (0.30%)	0.26
	No	134 (39.10%)	31 (9.00%)	6 (1.70%)	2 (0.60%)	
Eyelid edema	Yes	163 (47.50%)	4 (1.20%)	3 (0.90%)	0	0.54
	No	169 (49.30%)	3 (0.90%)	1 (0.30%)	0	
Sensation of sand in the eye	Yes	135 (39.40%)	30 (8.70%)	3 (0.90%)	2 (0.60%)	0.18
	No	149 (43.40%)	20 (5.80%)	4 (1.20%)	0	
Eye discharge	Yes	159 (46.40%)	8 (2.30%)	3 (0.90%)	0	0.14
	No	168 (49.00%)	5 (1.50%)	0	0	
Ocular pruritus	Yes	123 (35.90%)	36 (10.50%)	9 (2.60%)	2 (0.60%)	0.28
	No	140 (40.80%)	27 (7.90%)	5 (1.50%)	1 (0.30%)	
Photophobia	Yes	135 (39.40%)	19 (5.50%)	13 (3.80%)	3 (0.90%)	0.04*
	No	156 (45.50%)	9 (2.60%)	7 (2.00%)	1 (0.30%)	
Hemeralopia (night blindness)	Yes	154 (44.90%)	10 (2.90%)	4 (1.20%)	2 (0.60%)	0.16
	No	166 (48.40%)	4 (1.20%)	3 (0.90%)	0	
Burning sensation	Yes	120 (35.00%)	36 (10.50%)	13 (3.80%)	1 (0.30%)	0.17
	No	139 (40.50%)	22 (6.40%)	11 (3.20%)	1 (0.30%)	

Caption: *Chi-square test $p < 0.05$.

Source: Prepared by the authors (2025).

DISCUSSION

Based on the statistical results of the study, it was found that no association was identified between the use of protective measures and the intensity of ocular symptoms in workers exposed to surgical smoke. However, a statistically significant difference was observed in the presence of photophobia in relation to the use of glasses as a

protective measure. That is, workers who use glasses as protection tend to experience less photophobia than those who do not.

Low adherence to the PPEs is attributed to factors such as work overload, lack of time, scarcity of specific training, lack of institutional incentives, and a shortage of PPE. Lack of awareness about the importance of biosafety measures in the workplace also contributes to low adherence, as the use of PPE is conditioned by professionals' perception of the risks to which they are exposed. In addition, discomfort and technical difficulties associated with the use of equipment, due to loss of touch and flexibility, may be additional factors.[18-19]

A documentary, descriptive, and exploratory study, based on a narrative literature review, aimed to identify trends in scientific production in Brazilian theses and dissertations on worker health in SC. It analyzed the health of SC workers and observed that low adherence to the use of PPE exposes the team to occupational diseases. The study suggests that this practice may be related to a lack of knowledge among workers or the absence of educational policies that encourage prevention[20].

A study conducted in the operating room during the transoperative period identified the presence of Polycyclic Aromatic Hydrocarbons (PAHs) in the air, substances recognized as toxic and harmful to health. The study also revealed low adherence to the use of PPEs: no professional used an N95 mask, and 95% did not use protective eyewear. No member of the intraoperative team used adequate PPE in the face of exposure to surgical smoke, reinforcing the urgency of awareness strategies and the adoption of effective protection measures for healthcare workers[21].

Given this, the low adherence to the use of PPE by professionals on the intraoperative team, observed in this study, may be associated with a lack of training directed at the risks of surgical smoke in the institutions analyzed. The absence of continuing education strategies on the subject makes it difficult for workers to understand the relevance of protective measures.

Some studies indicated deficiencies in the use of PPE by the health team, showing that most have insufficient knowledge and neglect its use, which contributes to the increase in occupational risks[22].

The guidelines of Regulatory Standard - 6 (NR-6) establish that ocular PPE must meet the requirements for protection against different types of risks: impacts from objects and fragments, chemical splashes, irritating mists, and dust particles dispersed in the air [13-23].

Regarding the care of eye exposure, Law No. 6514/1977 establishes the regulation of the use of protective eyewear, addressing issues related to occupational medicine and safety. The regulation details the different types of eyewear indicated for each risk present in the work environment, considering the functions performed by workers. To minimize occupational risks associated with surgical smoke, protective eyewear is recommended as a way to prevent particle impacts on the eyes, but it must be considered that protective eyewear does not seal the smoke from contact with the eyes, which makes this type of protection incipient[13].

The chemical composition of surgical smoke includes formaldehyde, which, according to the National Cancer Institute (INCA), is toxic when inhaled, ingested, or in contact with mucous membranes. In high concentrations, it is classified as carcinogenic, with acute effects when in contact with the ocular mucosa, such as tearing, eye irritation, redness, and blurred vision[23].

Given the sensitivity of the eyes, which are especially susceptible to various types of particles, their protection is crucial in these locations to prevent burns or perforations. As for the models of protective eyewear, they include colorless ones, which protect against impacts from flying particles; wide-vision ones, which protect against various agents; and those against gases and vapors, which prevent eye irritation with a complete sealing system[13].

For eyewear to effectively perform its purpose as PPE to minimize occupational risks, it is necessary that it meets the standards, especially the American National Standards Institute (ANSI) Z87.1:2020, which establishes criteria for eye protection against impacts from volatile particles and intense light. In addition, it is essential that these glasses filter 99% of ultraviolet A (UVA) and ultraviolet B (UVB) radiation[25].

It is noteworthy that the studies found in the literature regarding surgical smoke do not detail the correct way and effectiveness of using protective eyewear as PPE, limiting themselves only to reporting its use or not by professionals.

Therefore, the correct use of PPE is essential to ensure the health and safety of workers during the handling of work instruments. Furthermore, the use of PPE also contributes to accident prevention, as work environments present risks to workers due to the nature of the activities performed, minimizing or even eliminating such risks[25].

AORN recommends occupational protection strategies to reduce the risks associated with exposure to surgical smoke, including the use of PPE such as surgical masks, protective eyewear, and gloves for individual skin safety[10]. However, there is no specification as to the type of eyewear that should be used.

Face shields, whether disposable or reusable, have been developed to protect various parts of the user's face against specific exposures. While wide-vision goggles aim to protect the eyes against splashes, sprays, and mists. Face shields have the function of reducing exposure not only to the eyes, but also to other areas of the face. However, it is important to note that, in isolation, face shields may not offer sufficient eye protection against airborne mists or aerosols[26].

Regulatory standards such as those of the United States of America (USA) Centers for Disease Control and Prevention (CDC) and the National Institute for Occupational Safety and Health (NIOSH) recommend the combined use of face shields with wide-vision goggles in situations requiring precautions for the control of airborne infections[27], such as in the case of surgical smoke.

Portable evacuation systems are equipment recommended by NIOSH to reduce exposure to surgical smoke by capturing and filtering it directly at the source of emission. In this study, the term "smoke extractor" used by the institutions referred to the fluid aspirator, as they did not have a specific system for this purpose. However, the effectiveness in removing particles from surgical smoke can reach up to 99%, depending on ideal conditions such as suction capacity, cutting angle, and volume flow rate[28], thus potentially reducing exposure to surgical smoke in contact with the eyes.

Given concerns about public health and the need to meet the guidelines of the 2030 Agenda, it is essential to promote safe and dignified work environments for healthcare professionals. This includes ensuring the protection of labor rights and compliance with environmental and health standards, in accordance with international agreements, especially the standards of the International Labour Organization (ILO)[29]. The issue in question reinforces the importance of studies that prove the effectiveness of the proper use of PPE for each type of risk, in addition to the need for training the intraoperative

team through training and continuing education actions on the risks of exposure to surgical smoke.

However, identifying ocular signs and symptoms related to occupational exposure to surgical smoke should influence public policies regarding the occupational health of healthcare workers, in addition to providing professionals with knowledge to workers exposed to occupational risks and forms of protection.

CONCLUSION

It is concluded that there was a statistically significant association between the presence of photophobia and the use of glasses as a protective measure. However, no statistical significance was identified between the intensity of ocular signs and symptoms and the other protective measures adopted in health services by workers exposed to surgical smoke.

Intraoperative team professionals reported using recommended PPE, such as surgical masks, N95 respirators, and protective eyewear. However, it was found that the use of this equipment is not always carried out properly, which compromises its effectiveness in preventing exposure to surgical smoke.

In light of these findings, the need for investigations that validate the effectiveness of the proper use of PPE according to the different risks of the surgical environment is highlighted. In addition, the importance of continuously training the intraoperative team through training and educational actions, focusing on awareness of occupational risks and the correct use of protective equipment, is emphasized.

The low adherence to the proper use of PPE may be related to the absence of institutional strategies for continuing education, which hinders workers' understanding of the importance of safety measures and compromises protection in the workplace.

REFERENCES

1. Martins FZ, Dall'Agnol CM. Surgical center: challenges and strategies for nurses in managerial activities. Rev Gaúcha Enferm [Internet]. 2016 [cited 2024 Jan 24];37(4):e56945. Available from: https://doi.org/10.1590/1983-1447.2016.04.56945

2. Liu Y, Song Y, Hu X, Yan L, Zhu X. Awareness of surgical smoke hazards and enhancement of surgical smoke prevention among the gynecologists. J Cancer [Internet]. 2019 [cited 2024 Mar 10];10(12):2788-99. Available from: https://doi.org/10.7150/jca.31464

3. Olgun Ş. Surgical smoke, precautions and employee awareness. Journal of Awareness [Internet]. 2020 [cited 2024 Feb 12];5(1):65-70. Available from: https://doi.org/10.26809/joa.5.005

4. Wu X, Li Y, Yao Y, Luo X, He X, Yin W. Development of construction workers job stress scale to study and the relationship between job stress and safety behavior: an empirical study in Beijing. Int J Environ Res Public Health [Internet]. 2018 [cited 2024 Mar 10];15(11):2409. Available from: https://doi.org/10.3390/ijerph15112409

5. Casey VJ, Martin C, Curtin P, Buckley K, McNamara LM. Comparison of surgical smoke generated during electrosurgery with aerosolized particulates from ultrasonic and high-speed cutting. Ann Biomed Eng [Internet]. 2021 [cited 2024 Jan 15];49(2):560-72. Available from: https://doi.org/10.1007/s10439-020-02587-w

6. Lewin JM, Brauer JA, Ostad A. Surgical smoke and the dermatologist. J Am Acad Dermatol [Internet]. 2011 [cited 2024 Feb 10];65(3):636-41. Available from: https://doi.org/10.1016/j.jaad.2010.11.017

7. Okubo CVC, Ribeiro RP, Martins JT, Marziale MHP. Polycyclic aromatic hydrocarbons: correlation between the time of electrocautery use and surgical time. Cogitare Enferm [Internet]. 2017 [cited 2024 Feb 12];22(3):e50115. Available from: https://doi.org/10.5380/ce.v22i3.50115

8. Bieniek AA, Aroni P, Costa RG, Ribeiro RP. Signs and symptoms related to surgical smoke exposure: integrative review. Rev SOBECC [Internet]. 2021 [cited 2024 Jan 20];26(3):189-96. Available from: https://doi.org/10.5327/Z1414-4425202100030009

9. National Institute for Occupational Safety and Health (NIOSH). Hospital Respiratory Protection Program Toolkit: Resources for Respirator Program Administrators [Internet]. Atlanta, GA: Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH); 2022 May [cited 2024 Feb 10]. Available from: https://doi.org/10.26616/NIOSHPUB2015117revised042022

10. Association of Perioperative Registered Nurses (AORN). Guidelines for perioperative practice. 8th ed. Denver: AORN; 2023. 999 p.

11. McQuail PM, McCartney BS, Baker JF, Kenny P. Diathermy awareness among surgeons-An analysis in Ireland. Ann Med Surg (Lond) [Internet]. 2016 [cited 2024 Jan 10];12:54-9. Available from: https://doi.org/10.1016/j.amsu.2016.10.006

12. Gao S, Koehler RH, Yermakov M, Grinshpun SA. Performance of facepiece respirators and surgical masks against surgical smoke: simulated workplace protection factor study. Ann Occup Hyg [Internet]. 2016 [cited 2024 Mar 10];60(5):608-18. Available from: https://doi.org/10.1093/annhyg/mew006

13. Ministério do Trabalho e Emprego (BR). Norma Regulamentadora NR 06 - Equipamento de Proteção Individual – EPI. Brasília, DF: Ministério do Trabalho e Emprego; 2022 [cited 2025 Sep 21]. Available from: https://www.gov.br/trabalho-e-emprego/pt-br/acesso-a-informacao/participacao-social/conselhos-e-orgaos-colegiados/comissao-tripartite-partitaria-permanente/normas-regulamentadora/normas-regulamentadoras-vigentes/nr-06-atualizada-2025-ii.pdf

14. Polit DF, Beck CT, Hungler BP. Fundamentos de pesquisa em enfermagem: métodos, avaliação e utilização. 5. ed. Porto Alegre: Artmed; 2011. 487 p.

15. Friis RH, Sellers TA. Epidemiology for public health practice. 4th ed. Sudbury: Jones & Bartlett Learning; 2008. 717 p.

16. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol [Internet]. 2008 [cited 2024 Feb 10];61(4):344-9. Available from: https://doi.org/10.1016/j.jclinepi.2007.11.008

17. Bieniek AA, Leachi HFL, Ribeiro RP. Construção e validação da escala de intensidade dos sinais e sintomas relacionados à fumaça cirúrgica. Braz J Dev [Internet]. 2022 [cited 2024 Jan 10];8(5):41375-88. Available from: https://doi.org/10.34117/bjdv8n5-567

18. La-Rotta EIG, Garcia CS, Pertuz CM, Miquilin IOC, Camisão AR, Trevisan DD, et al. Knowledge and compliance as factors associated with needlestick injuries contaminated with biological material Brazil and Colombia. Ciênc Saúde Coletiva [Internet]. 2020 [cited 2024 Jan 12];25(2):715-27. Available from: https://doi.org/10.1590/1413-81232020252.04812018

19. Magalhães MWB, Lopes RS, Lima ALS, Silva FTA, Silva HDP, Leite MKM, et al. Análise do uso de materiais de biossegurança por profissionais da área da saúde no ambiente hospitalar: uma revisão integrativa. Acervo Científico [Internet]. 2021 [cited 2024 Feb 10];28:e6994. Available from: https://doi.org/10.25248/reac.e6994.2021

20. Peserico A, Beck CLC, da Silva RM, Coelho APF, Jacobi CS. Saúde do trabalhador de centro cirúrgico: análise das tendências em teses e dissertações. Rev Recien [Internet]. 2021 [cited 2024 Feb 10];11(36):434-50. Available from: https://doi.org/10.24276/rrecien2021.11.36.434-450

21. Claudio CV, Ribeiro RP, Martins JT, Marziale MHP, Solci MC, Dalmas JC. Polycyclic aromatic hydrocarbons produced by electrocautery smoke
and the use of personal protective equipment. Rev Latino-Am Enfermagem [Internet]. 2017 [cited 2025 May 23];25:e2853. Available from: https://doi.org/10.1590/1518-8345.1561.2853

22. Mallmann DG, Sousa JC, Hammerschmidt KS. Acidentes de trabalho e sua prevenção na produção científica brasileira de enfermeiros: revisão integrativa. Ciênc Saúde (Porto Alegre) [Internet]. 2016 [cited 2024 Jan 10];9(1):49-54. Available from: https://doi.org/10.15448/1983-652X.2016.1.21810

23. Instituto Nacional de Câncer (INCA) [Internet]. Rio de Janeiro: INCA; 2022 [cited 2024 Feb 12]. Benzeno;[about 3 screens]. Available from: https://www.gov.br/inca/pt-br/assuntos/causas-e-prevencao-do-cancer/exposicao-no-trabalho-e-no-ambiente/solventes/benzeno

24. Ministério do Trabalho e Emprego (BR). Norma Regulamentadora 15 - Portaria MTB n° 3.214, de 8 de junho de 1978, estabelece as Atividades e Operações Insalubres. Anexo 11- Agentes químicos cuja insalubridade é caracterizada por limite de tolerância e inspiração no local de trabalho [Internet]. Brasília: MTE; 1978 [cited 2024 Mar 12]. 5 p. Available from: https://www.gov.br/trabalho-e-emprego/pt-br/acesso-a-informacao/participacao-social/conselhos-e-orgaos-colegiados/comissao-tripartite-partitaria-permanente/normas-regulamentadora/normas-regulamentadoras-vigentes/norma-regulamentadora-no-15-nr-15

25. Tribunal Superior do Trabalho (BR). EPIs desempenham papel fundamental na luta pela redução de acidentes de trabalho. Justiça do Trabalho – Tribunal Superior do Trabalho [Internet]. 2021 Jul 27 [cited 2024 Mar 12];Notícias do TST:[about 5 screens]. Available from: https://www.tst.jus.br/-/epis-desempenham-papel-fundamental-na-luta-pela-redu%C3%A7%C3%A3o-de-acidentes-de-trabalho-2

26. International Safety Equipment Association. ANSI/ISEA Z87.1-2020: American National Standard for Occupational and Educational personal eye and face protection devices [Internet]. Virginia: International Safety Equipment Association; c2020 [cited 2024 Feb 12]. Available from: https://shannonoptical.com/wp-content/uploads/2023/07/ANSI-ISEA-Z87-1-2020.pdf

27. Centers for Disease Control and Prevention (US), National Institute for Occupational Safety and Health (NIOSH). Eye safety – infection control [Internet]. Atlanta (GA): CDC; 2013 Jul 29 [cited 2024 Feb 12]. Available from: https://archive.cdc.gov/www_cdc_gov/niosh/topics/eye/eye-infectious.html

28. Fischer S, Thieves M, Hirsch T, Fischer KD, Hubert H, Beppler S, et al. Reduction of airborne bacterial burden in the OR by Installation of Unidirectional Displacement Airflow (UDF) systems. Med Sci Monit [Internet]. 2015 [cited 2024 Jan 10];21:2367-74. Available from: https://doi.org/10.12659/MSM.894251

29. Organizacio´n Panamericana de la Salud. Salud em las Américas: panorama regionaly perfiles de país [Internet]. Washington, DC: OPS; 2012 [cited 2024 Mar 20]. 223 p. Available from: https://iris.paho.org/handle/10665.2/3272

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