INTRAOPERATIVE SURGICAL SMOKE: OCCUPATIONAL SAFETY MEASURES PROPOSED BY SPECIALIST NURSES

Fumaça cirúrgica no intraoperatório: medidas de segurança ocupacional propostas por enfermeiros especialistas

Humo quirúrgico intraoperatorio: medidas de seguridad ocupacional propuestas por enfermeras especialistas

Patrícia Treviso[1]*, Brenda Carvalho Peradotto[1], Juliana Vargas Campiol[1], Neide da Silva Knihs[2], Marcia Cristina de Oliveira Pereira[3], Giovana Abrahão de Araújo Moriya[4]

ABSTRACT: Objective: To describe measures proposed by nurses specialized in surgical center (SC) to reduce inhalation of electrocoagulation smoke in the intraoperative period and improve occupational safety. **Method:** This is a qualitative study based on data from a scientific meeting of SC specialists about the inhalation of electrocoagulation smoke. The meeting was held in São Paulo in 2019, lasted one hour, and was audio-recorded. The SC-specialist nurses who participated were randomly divided into four groups. The unavailability to participate in the entire meeting was considered an exclusion criterion. The data corpus consisted of: recording of the meeting and reports of the groups, followed by thematic analysis. **Results:** Twenty-one nurses, most of them women, from seven Brazilian states participated in the meeting. They suggested the following measures to decrease smoke inhalation and improve occupational safety: technology to reduce and/or suction smoke; surgical or N95 mask; room exhaust system; establishment of regulations; continuing education. **Conclusions:** Measures to reduce smoke inhalation and increase team safety in the intraoperative period include technologies to reduce smoke, use of personal protective equipment, establishment of regulations, and continuing education.

Keywords: Smoke. Electrocoagulation. Occupational health. Biomedical technology. Intraoperative period.

RESUMO: Objetivo: Descrever medidas propostas por enfermeiros especialistas em centro cirúrgico (CC) para reduzir a inalação de fumaça proveniente da eletrocoagulação no intraoperatório e melhorar a segurança ocupacional. **Método:** Estudo qualitativo, com dados oriundos de reunião científica com especialistas em CC realizada em 2019, em São Paulo, com duração de uma hora, gravada em áudio, acerca da inalação de fumaça oriunda da eletrocoagulação. Participaram enfermeiros especialistas em CC, divididos aleatoriamente em quatro grupos. Considerou-se a indisponibilidade para participar da reunião na íntegra um critério de exclusão. Compuseram o *corpus* de dados: gravação da reunião e registros dos grupos, e procedeu-se a análise temática. **Resultados:** Participaram 21 enfermeiros de sete estados brasileiros, a maioria mulheres. Foram apontadas medidas para diminuir a inalação de fumaça e melhorar segurança ocupacional: tecnologia para reduzir e/ou aspirar fumaça; máscara N95; sistema de exaustão de sala; estabelecimento de normativas; educação permanente. **Conclusão:** Medidas para reduzir a inalação de fumaça e aumentar a segurança da equipe no intraoperatório incluem tecnologias para reduzir a fumaça, uso de equipamentos de proteção individual, estabelecimento de normativas e educação permanente.

Palavras-chave: Fumaça. Eletrocoagulação. Saúde do trabalhador. Enfermagem perioperatória. Período intraoperatório.

[1]Universidade do Vale do Rio dos Sinos – São Leopoldo (RS), Brazil.
[2]Universidade Federal de São Paulo – São Paulo (SP), Brazil.
[3]Universidade Federal de Santa Catarina – Florianópolis (SC), Brazil.
[4]Universidade de São Paulo – São Paulo (SP), Brazil.
*Corresponding author: ptreviso15@gmail.com
Received: 11/26/2021 – Approved: 12/13/2021
https://doi.org/10.5327/Z1414-4425202100040005

RESUMEN: **Objetivo:** Describir las medidas propuestas por enfermeros especialistas en el Quirófano (Q) para reducir la inhalación de humo intraoperatorio por electrocoagulación y mejorar la seguridad ocupacional. **Método:** Estudio cualitativo, con datos de una reunión científica con expertos en Q realizada en 2019, en São Paulo, de una hora, grabada en audio, sobre la inhalación de humo por electrocoagulación. Participaron enfermeros especialistas en Q, divididos aleatoriamente en cuatro grupos. La falta de disponibilidad para participar plenamente en la reunión se consideró un criterio de exclusión. Se compuso el corpus de datos: grabación de la reunión y actas de los grupos, y se realizó el análisis temático. **Resultados:** Participaron 21 enfermeras de siete estados brasileños, la mayoría mujeres. Se identificaron medidas para reducir la inhalación de humo y mejorar la seguridad ocupacional: tecnología para reducir y/o inhalar humo; mascarilla quirúrgica o N95; sistema de escape de la habitación; establecimiento de regulaciones; Educación permanente. **Conclusión:** Las medidas para reducir la inhalación de humo y aumentar la seguridad del equipo intraoperatorio incluyen tecnologías para reducir el humo, uso de equipo de protección personal, establecimiento de regulaciones y educación continua.

Palabras clave: Humo. Electrocoagulación. Salud laboral. Tecnología biomédica. Enfermería perioperatoria. Periodo intraoperatorio.

INTRODUCTION

Surgical smoke originates from the use of electrosurgical equipment in tissue dissection and coagulation processes and may be toxic to the health team in the operating room (OR)[1]. Known to produce surgical smoke, the equipment used in the intraoperative period, including electrosurgical devices, laser ablation devices, electrocauteries, and ultrasonic devices, can raise the temperature of the tissue to the point of rupturing the cells and releasing particles into the environment[2].

This smoke consists of water vapor and chemical compounds, such as toluene, xylene, ethylbenzene, butyl acetate, acrylonitrile, 1,2-dichloroethane, phenol, chlorine, cyanide, hydrogen cyanide, carbon monoxide, and polycyclic aromatic hydrocarbons (PAH), which, in large part, have naphthalene, a possible human carcinogen[3-5]. Another element also present in surgical smoke is benzene, at a concentration hundreds of times higher than the exposure limit established by the National Institute for Occupational Safety and Health (NIOSH), a United States regulatory agency[6]. In addition to chemicals, biological elements such as viral deoxyribonucleic acid (DNA) components can also be identified in surgical smoke[7].

The size and morphology of smoke particles influence the effectiveness of protection measures and vary according to the tissue and type of incision[8]. The electrocauterization technique, for example, produces particles with a smaller mean aerodynamic size (0.07 µm), while laser tissue ablation creates larger particles (0.31 µm)[9].

The protection afforded by surgical masks only applies to particles larger than 0.9 µm[10]. The N95 mask, in turn, ensures that no particle greater than 0.3 µm is inhaled[11]. In addition, when used in the OR, some smoke evacuation systems remove particles larger than 0.12 µm from the environment, preventing the professionals from inhaling them[2,8].

Signs and symptoms related to smoke inhalation vary, but the most frequently reported by professionals working in the intraoperative period are: headache, lacrimation, cough, sore throat, unpleasant smell, nausea, drowsiness, dizziness, sneezing, and rhinitis[12,13]. However, there is a risk for more severe diseases, such as alveolar congestion, interstitial pneumonia, bronchiolitis, and emphysematous changes in the respiratory tract[1].

Discussions by nurses are extremely important to bring to light possible risks arising from exposure to surgical smoke since these professionals are involved in all surgical center (SC) processes and are responsible for managing the service, justifying the performance of this study.

Thus, the guiding question is: what measures should be taken to reduce the inhalation of electrocoagulation smoke in the intraoperative period and improve occupational safety?

OBJECTIVE

To describe measures proposed by SC-specialist nurses to reduce inhalation of electrocoagulation smoke in the intraoperative period and improve occupational safety.

METHOD

This is an exploratory, descriptive, qualitative study. Data were collected from a scientific meeting of SC specialists held during the 14th Congress of the Brazilian Association of Surgical Center, Anesthesia Recovery, and Sterile Processing Department Nurses (*Associação Brasileira de Enfermeiros de*

Centro Cirúrgico, Recuperação Anestésica e Centro de Material e Esterilização — SOBECC), in the city of São Paulo, in September 2019. The meeting lasted one hour and discussed the inhalation of electrocoagulation smoke in the intraoperative period.

SC-specialist nurses from several country regions were invited to participate in the study. Professionals attending the Congress were intentionally invited. The participants were informed of the purpose of the activity and how it would happen. Those who agreed to participate in the study signed an Informed Consent Form (ICF).

The inclusion criteria were: being a nurse, having experience in surgical nursing, and participating in the congress. The unavailability to participate in the entire scientific meeting was considered an exclusion criterion.

Participants were randomly divided into four groups — one group with six members and the remaining tables with five nurses each. Each group elected an interlocutor to moderate the discussion and a person responsible for recording the discussion. They received paper, pen, flip chart, and six numbered envelopes, each containing a question for the group to discuss sequentially.

The interlocutor was instructed to open an envelope at a time, starting the discussion on each question. One of the participants should make a brief report of the points discussed and the responses elicited. They were encouraged to discuss each question for 5 to 7 minutes.

The questions covered the following topics: risks associated with surgical smoke; professional categories exposed to it; exposure time; signs and symptoms related to inhalation of this type of smoke; measures to reduce smoke inhalation by the team; and measures to increase occupational safety connected to smoke.

After 35 minutes, each group presented the discussion results based on the questions using the flip chart. All interlocutors disclosed the answers from their groups. These answers were documented in the flip chart and audio-recorded. The general discussion was moderated by the main researcher and an assistant researcher.

At the end of the scientific meeting, the groups delivered the reports to the researchers. Together with the recording, which was later transcribed, these reports comprised the data corpus of this study. Next, we performed thematic data analysis.

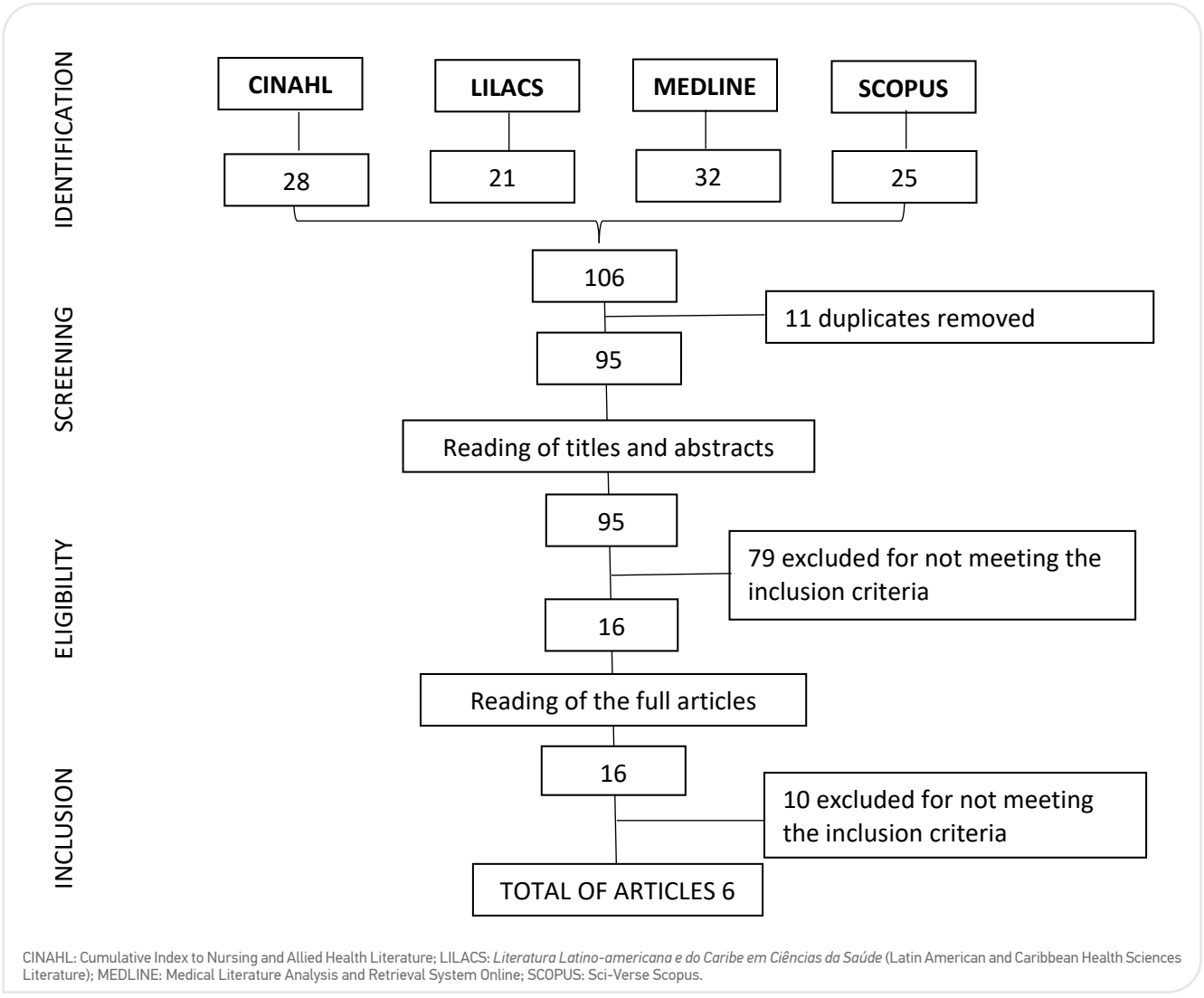
The study complied with Resolution no. 466/2012 of the Brazilian National Health Council. The Research Ethics Committee approved this project (Certificate of Presentation for Ethical Consideration/*Certificado de Apresentação para Apreciação Ética* — CAAE 33693320.6.0000.5308).

In order to strengthen the study, we also performed an integrative literature review. The six stages of the integrative review were followed: identifying the theme and selecting the research question, establishing the criteria for sample selection, defining the information to be extracted from the selected articles, assessing the studies included in the integrative review, analyzing the results, presenting and synthesizing the knowledge[14].

In the first stage, the research question was elaborated according to the Patient or Problem, Intervention, Comparison, and Outcomes (PICO) strategy, in which: (P) inhalation of electrocoagulation smoke by the surgical team; (I) intraoperative care; and (O) recommendations for occupational safety. In this case, comparison (C) was not used. Therefore, the following question was defined: based on scientific evidence, what are the recommendations for occupational safety regarding electrocoagulation smoke in the intraoperative period?

In the second stage, data were collected by consulting the databases: Medical Literature Analysis and Retrieval System Online (Medline), Latin American and Caribbean Health Sciences Literature (*Literatura Latino-americana e do Caribe em Ciências da Saúde* — LILACS), Sci-Verse Scopus (SCOPUS), and Cumulative Index to Nursing and Allied Health Literature (CINAHL). We included primary studies, with no language restriction, published in the past five years (2017–2021). Search strategies were based on the Health Sciences Descriptors (*Descritores em Ciências da Saúde* — DeCS) "electrosurgery", "plume", "surgery smoke" and the boolean operator "AND".

In the third stage, after identifying 106 studies, we used the Mendeley reference manager, removing 11 duplicates from the different databases. Next, two independent reviewers read the titles and abstracts, excluding those that did not meet the inclusion criteria or match the proposed theme. Sixteen studies were selected for full reading, a step performed by two independent reviewers to help validate the selection of articles for analysis. For this analysis, the reviewers considered the inclusion and exclusion criteria and the research question, resulting in six articles, which comprised the sample of this review. To better understand the selection of the material obtained, we used an adapted version of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) flowchart, as shown in Figure 1[15].



CINAHL: Cumulative Index to Nursing and Allied Health Literature; LILACS: *Literatura Latino-americana e do Caribe em Ciências da Saúde* (Latin American and Caribbean Health Sciences Literature); MEDLINE: Medical Literature Analysis and Retrieval System Online; SCOPUS: Sci-Verse Scopus.

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews flowchart for the selection of articles comprising the sample.

In the fourth stage, evidence was extracted by analyzing, interpreting, and synthesizing the publications selected for the sample through the elaboration of a synoptic table consisting of title, year, objective, methodological design of the study, treatment evidence, and level of evidence. This step was also performed by two independent reviewers. The information collected comprised the data corpus of the research.

The quality of the articles was assessed based on the classification of the level of evidence, following recommendations from the Oxford Centre for Evidence-Based Medicine[16], which categorizes the studies into five levels:

I) systematic review of randomized trials;
II) randomized trial;
III) non-randomized cohort/follow-up studies;
IV) case studies or case-control studies;
V) expert opinion or opinion based on standards and legislation.

In the fifth stage, data were analyzed from the perspective of the thematic analysis, and three categories were established: "surgical smoke components"; "risks and effects of surgical smoke inhalation on human health"; and "occupational safety measures".

In the sixth stage, results were presented, and data were descriptively discussed, allowing us to identify the measures

to improve occupational safety related to electrocoagulation smoke in the intraoperative period.

RESULTS

Twenty-one SC-specialist nurses from various country regions attended the meeting — one participant from each of the following states: Santa Catarina, Espírito Santo, Bahia, and Pará; three participants from Rio de Janeiro; four from Rio Grande do Sul; ten from São Paulo. The participants were mainly women (17/81.0%).

The measures described by the professionals to reduce inhalation of electrocoagulation smoke in the intraoperative period were: adopting technology to suction electrocautery smoke before it disperses in the OR, monitored by clinical engineering; using High-Efficiency Particulate Air (HEPA) filters in the OR; using masks for particle filtration. As for measures to increase the safety of professionals with respect to smoke inhalation, the specialists cited: continuing and permanent education; establishment of institutional policies; adoption of technologies that produce less smoke; use of microparticle filtration masks; disclosure of risks through scientific evidence; use of a smoke suction device; installation of an exhaust system; and elaboration of national regulations, aiming at greater safety concerning electrocoagulation smoke (Chart 1).

The presentation of articles included in the integrative review contains: authorship; year of publication and country; design and sample; interventions; outcomes; and level of evidence (Chart 2).

Based on the thematic analysis, data from the integrative review were organized into three categories (Chart 3).

DISCUSSION

Half of the articles included in the integrative review were performed in Brazil, which shows the interest of Brazilian researchers in the impacts of surgical smoke[4,13,17]. However, according to the primary results of this study, discussions on this subject in health facilities are still incipient in our country. Out of the four groups of professionals, only one reported having, in one of the facilities, meetings on the subject and proposals to implement technology for smoke suction. That same hospital already uses suction in surgical

Chart 1. Questions and results of the scientific meeting held during the 14th Congress of the Brazilian Association of Surgical Center, Anesthesia Recovery, and Sterile Processing Department Nurses, in São Paulo, September 2019.

Questions	Group 1	Group 2	Group 3	Group 4
1. Does the facility where you work hold discussions about surgical smoke?	Incipient or non-existent.	There is no discussion on the subject; however, some surgeons have requested smoke suction equipment.	A hospital held meetings to implement smoke suction technology for a year (since 2018). The same professional mentions the availability of a high-frequency suction device for human papillomavirus (HPV) lesions in the hospital where they work.	This subject is not addressed in the facility.
2. What are the risks of surgical smoke?	Microbiological risks.	Microbiological risks, mainly associated with HPV, the dispersion of cancer cells and chemotherapeutic agents in surgeries that involve intraoperative chemotherapy.	Risk of implications for the respiratory and cardiac systems of the professionals, upper airway irritation, eye irritation, cancer.	Nausea, vomiting, eye irritation. Little is known about the subject, making it difficult to establish a causal connection.

Continue...

Chart 1. Continuation.

Questions	Group 1	Group 2	Group 3	Group 4
3. Which professionals inhale surgical smoke?	Professionals of the surgical team who stay in the OR, such as surgeons, the nursing team, anesthesiologists, and the patient.	Everyone in the operating room, especially those close to the surgical field, including the surgical team, surgical technologist, and anesthesiologist.	All professionals in the operating room, the patient, and the staff working close to the operating room.	Physicians, assistants, surgical technologists, circulating nurses, perfusionists in the operating room, as well as X-ray technicians and other people who provide support in the room.
4. For how long does the team working in the operating room inhale the surgical smoke?	While they are working: 6 hours, 8 hours, 12 hours (depending on their shift).	During and after the use of the electric scalpel. It also depends on the type and specialty of the surgery, the length of the procedure, and how long the equipment was used.	From the moment the smoke-generating equipment starts being used to approximately 20 minutes after use.	It varies, depending on how long the technology is used. Some variables need to be considered for mapping the exposure, such as: complexity of each procedure, type of surgery, whether they are intracavitary or video-assisted surgeries.
5. Has any professional ever mentioned discomfort or symptoms caused by surgical smoke inhalation? If so, what discomfort or symptom has been reported to you?	Yes. Frequent upper airways problems, such as airway irritation, odor-related discomfort. However, making a causal connection is difficult since we also have to consider the room temperature, the use of air conditioning, and the presence of suspended particles, in addition to smoke.	Yes. Discomfort related to the smell of electrocoagulation. Airway irritation. Eye burning.	Yes, both by professionals and students. Respiratory distress, aversion to the smell produced by electrocoagulation.	Yes. Cough, eye itching, runny nose, nausea, vomiting, odor-related discomfort.
6. What measures could be taken to: a) reduce surgical smoke inhalation in the intraoperative period; b) increase the safety of the surgical team with respect to smoke inhalation in the intraoperative period?	a) invest in technology, improve the quality of the masks, invest in specific devices, such as smoke suction devices, smoke evacuation systems, High Efficiency Particulate Air (HEPA) filters; invest in education and awareness of the medical and nursing teams. b) perform continuing education actions involving all professionals in the sector.	a) adhere to evidence-based best practices concerning the use of electrosurgical equipment. b) establish institutional policies; use smoke suction devices; acquire new devices with complete sealing.	a) adopt technologies available in the market, from accessories to surgical smoke suction devices, with clinical engineering monitoring. Perform continuing education activities for the multidisciplinary team. b) adopt technologies that produce less and/or no smoke; use microparticle filtration masks; raise awareness among the entire multidisciplinary team about the use of protective technologies. Disclose the risks through scientific evidence.	a) provide education linked to the patient's safety center; worker's health; independent commission of care-related infections. Since this is an occupational risk, there must be institutional concern. We lack national regulations and resolutions for more up-to-date practices on this subject. b) use equipment such as smoke suction devices and room exhaust systems according to the current legislation.

Chart 2. Summary of the articles included in the integrative review.

Reference	Year and country	Design and sample	Interventions	Outcomes	Level of evidence
Okubo *et al.* (2017)[4]	2019 Brazil	Quantitative cross-sectional study. n=50	Collection of hydrocarbons through a suction pump and identification by liquid chromatography.	Detection of hydrocarbons and low correlation between the production of these compounds and the time of electrocautery use.	III
Casey *et al.* (2021)[8]	2020 Ireland	Qualitative study. n=3	Use of three different cutting methods to collect information about the aerosol produced in all three procedures.	Higher prevalence of carbon and oxygen molecules in the samples.	III
Stanganelli *et al.* (2019)[13]	2019 Brazil	Cohort study. n=39	Administration of a questionnaire about signs and symptoms that the literature relates to surgical smoke exposure.	The most prevalent symptoms were eye irritation, burning sensation in the pharynx, nausea, vomiting.	III
Claudio *et al.* (2017)[17]	2017 Brazil	Cross-sectional study. n=50	Gas collection by vacuum suction pump and gas chromatography reading.	Hydrocarbons detected in the air of operating rooms in 100% of surgeries.	III
Hu *et al.* (2021)[18]	2020 China	Quantitative cross-sectional study. n=700	Nasal swab collection from gynecologists to detect human papillomavirus (HPV).	The rate of HPV infection in the nasal epithelial cells of participants who performed electrosurgery was significantly higher than among those who did not.	III
Michaelis *et al.* (2020)[19]	2020 Germany	Qualitative study. n=501	Administration of a questionnaire on sociodemographic data and perceived dangers of surgical smoke according to health professionals.	Half of the surgeons classified the health risks related to surgical smoke without protective measures as high or very high. Nurses showed greater health concern than surgeons. Smoke risks: headache, rhinitis, asthma, pneumonia.	V

Chart 3. Surgical smoke components, risks related to surgical smoke inhalation, and occupational safety measures.

Surgical smoke components
Hydrocarbons[4,13,17]
Human papillomavirus (HPV)[18]
Biological material[8]
Carcinogenic material[17]
Risks and effects of surgical smoke inhalation on human health
Transmission of HPV deoxyribonucleic acid (DNA)[18]
Interstitial pneumonia[8]
Bronchiolar hypertrophy and hyperplasia[8]
Eye irritation[13]
Burning sensation in the pharynx[13]
Nausea and vomiting[13]
Occupational safety measures
Surgical and N95 masks[8,13,17-19]
Smoke suction devices[13,17,19]

procedures for electrocauterization of human papillomavirus (HPV) lesions.

A study conducted in China showed that surgical smoke might carry biological material[1]. In another study published in 2020, nasal swab was collected from 700 gynecologists from 67 hospitals who performed electrosurgery, including loop electrosurgical excision procedures, aiming to identify whether these professionals were at risk of acquiring HPV DNA through surgical smoke. The rate of HPV infection in the nasal epithelial cells of the participants who performed electrosurgery was higher (8.96%) than in those who did not perform electrosurgery (1.73%), evidencing that gynecologists from the first group were at risk of HPV infection[18].

Participants of this study mentioned the following risks of surgical smoke inhalation: microbiological risks (HPV) due to cell dispersion through electrocoagulation smoke; risks to the respiratory and cardiac systems; eye irritation; nausea and vomiting. The integrative review also addresses these risks: eye irritation[13]; nausea and vomiting[13];

presence of biological material[8]; presence of carcinogenic material[17]; interstitial pneumonia[8]; bronchiolar hypertrophy and hyperplasia[8].

Of note, the specialist nurses from the four groups participating in this study mentioned that professionals working in the SC have complained of discomfort associated with smoke inhalation, such as: upper airway irritation, respiratory distress, runny nose, aversion to the smell produced by electrocoagulation, nausea, vomiting, coughing, and eye irritation. Nonetheless, we underline that two groups reported that these symptoms are not always associated with surgical smoke, making it difficult to make a causal connection. Group 1 declared that these symptoms are sometimes related to temperature, air conditioning use in the OR, and the possible presence of other particles in the environment. On the other hand, Group 4 pointed out that little is known about the subject.

Electrocoagulation smoke is produced when the equipment tip touches human tissue. Unless some suction and exhaust mechanism is used[19], this smoke is dispersed throughout the environment, posing risks related to the particulate matter and its chemical and biological composition[1,20].

The groups stated that all professionals in or near the OR, as well as the patient, are exposed to the risks of surgical smoke inhalation. In general, surgeons, anesthesiologists, surgical technologists, circulating nurses, and nurses are present in the OR[21]. However, other professionals may also be in the room, depending on the surgical procedure being performed or the need for support in the use of surgical technology. These professionals include clinical engineers, perfusionists, and X-ray technicians, who are also exposed to the risks of surgical smoke.

The measures suggested by the participants to reduce smoke inhalation in the intraoperative period are: adopting technology to suction electrocoagulation smoke; using HEPA filters; using facial masks with higher particle filtration; and complete sealing. Three articles[13,17,19] of the integrative review mentioned the use of smoke suction devices, and five articles[8,13,17-19] cited the use of surgical or N95 masks.

A study conducted in China in 2020 revealed that the detection rate of HPV particles in participants who used surgical masks (7.64%) was lower than in those who did not use protection (24.32%). Regarding the use of N95 masks, the detection of HPV particles was 0% compared to other types of masks (13.98%)[18].

Both measures — use of surgical or N95 mask and use of technology to suction smoke before it spreads in the OR — are considered crucial for the occupational safety of the professionals in the room, as well as for patient safety[1].

The study participants also suggested other measures aimed at occupational safety: investing in continuing education for the multidisciplinary team; establishing institutional policies; adopting technologies that produce less smoke; using technology for smoke suction; using microparticle filtration masks; installing an air exhaust system in the OR; raising awareness about the use of technologies among the multidisciplinary teams; performing research on the subject; disclosing the risks through scientific evidence; elaborating documents aimed at national regulations and resolutions for safer practice.

These results expand the knowledge of the subject investigated, providing elements for better safety for professionals working in the SC, especially in the OR. Since nurses work both in care and SC management, they need to know the risks and complications resulting from surgical smoke inhalation and propose, together with the multidisciplinary team, measures to reduce the exposure of professionals to smoke. They should also contribute to the elaboration of guiding documents and continuing education actions, aiming at the safety of those in the OR.

Study limitations

The study was based on a strategy to raise awareness among nurses from several Brazilian states, seeking to discuss a current and relevant theme to the safety of the surgical team. However, as the groups consisted of professionals from different facilities and realities, we could not verify the specific reality of each facility, which would certainly enrich the study. This is, therefore, a suggestion for new investigations. We also stress the need for primary studies that analyze the Brazilian context.

FINAL CONSIDERATIONS

Electrocoagulation smoke poses chemical and biological risks to professionals in the OR related to its inhalation during the intraoperative period. Exposed individuals may present symptoms such as upper airway irritation, cough, bronchiolitis, eye irritation or itching, nausea, and vomiting, among others.

The measures proposed by the participants to reduce surgical smoke inhalation and increase team safety in the intraoperative period include continuing education and the use of technologies such as: equipment with lower particle emission and with

a smoke suction device, microparticle filtration facial masks, room exhaust system, and elaboration and/or implementation of protocols aimed at greater safety of the professionals.

FUNDING

None.

CONFLICT OF INTERESTS

The authors declare there is no conflict of interests.

AUTHORS' CONTRIBUTION

PT: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project management, Resources, Supervision, Validation, Visualization, Writing — original draft, Writing — review & editing. **BCP:** Data curation, Formal analysis, Writing — original draft, Writing — review & editing. **JVC:** Data curation, Formal analysis, Writing — original draft, Writing — review & editing. **NSK:** Validation, Visualization, Writing — review & editing. **MCOP:** Conceptualization, Methodology, Validation, Visualization. **GAAM:** Conceptualization, Methodology, Validation, Visualization.

REFERENCES

1. 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. 2019;10(12):2788-99. https://doi.org/10.7150/jca.31464

2. Tan E, Russell K. Surgical plume and its implications: a review of the risk and barriers to a safe work place. J Perioper Nurs. 2017;30(4):33-9. https://doi.org/10.26550/2209-1092.1019

3. Liu Y, Zhao M, Shao Y, Yan L, Zhu X. Chemical composition of surgical smoke produced during Loop electrosurgical excision procedure treating cervical intraepithelial neoplasia. ResearchGate. 2021;1-19. https://doi.org/10.21203/rs.2.20593/v1

4. Okubo CVC, Ribeiro RP, Martins JT, Marziale MHP. Hidrocarbonetos policíclicos aromáticos: correlação entre tempo de uso do eletrocautério e tempo cirúrgico. Cogitare Enferm. 2017;22(3):e50115. https://doi.org/10.5380/ce.v22i3.50115

5. Andréasson SN, Mahteme H, Sahlberg B, Anundi H. Polycyclic aromatic hydrocarbons in electrocautery smoke during peritonectomy procedures. J Environ Public Health. 2012;2012:929053. https://doi.org/10.1155/2012/929053

6. Petrus M, Bratu AM, Patachia M, Dumitras DC. Spectroscopic analysis of surgical smoke produced in vitro by laser vaporization of animal tissues in a closed gaseous environment. Rom Reports Phys [Internet]. 2015 [acessado 25 mar. 2021];67(3):954-65. [accessed on Mar 25, 2021]. Available at: http://www.rrp.infim.ro/2015_67_3/A17.pdf

7. Mowbray N, Ansell J, Warren N, Wall P, Torkington J. Is surgical smoke harmful to theater staff? A systematic review. Surg Endosc. 2013;27(9):3100-7. https://doi.org/10.1007/s00464-013-2940-5

8. 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. 2021;49(2):560-72. https://doi.org/10.1007/s10439-020-02587-w

9. Lewin JM, Brauer JA, Ostad A. Surgical smoke and the dermatologist. J Am Acad Dermatol. 2011;65(3):636-41. https://doi.org/10.1016/j.jaad.2010.11.017

10. McQuail PM, McCartney BS, Baker JF, Kenny P. Diathermy awareness among surgeons – an analysis in Ireland. Ann Med Surg. 2016;12:54-9. https://doi.org/10.1016/j.amsu.2016.10.006

11. 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. 2016;60(5):608-18. https://doi.org/10.1093/annhyg/mew006

12. Ilce A, Yuzden GE, Giersbergen MY. The examination of problems experienced by nurses and doctors associated with exposure to surgical smoke and the necessary precautions. J Clin Nurs. 2017;26(11-12):1555-61. https://doi.org/10.1111/jocn.13455

13. Stanganelli NC, Bieniek AA, Margatho AS, Galdino MJQ, Barbosa KH, Ribeiro RP. Inalação da fumaça cirúrgica: coorte de sinais e sintomas em residentes. Acta Paul Enferm. 2019;32(4):382-9. https://doi.org/10.1590/1982-0194201900053

14. Mendes KDS, Silveira RCCP, Galvão CM. Revisão integrativa: método de pesquisa para a incorporação de evidências na saúde e na enfermagem. Texto Contexto Enferm. 2008;17(4):758-64. https://doi.org/10.1590/s0104-07072008000400018

15. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. 2018;2(7):467-73. https://doi.org/10.7326/m18-0850

16. Oxford Centre for Evidence-based Medicine. Levels of Evidence Working Group [Internet]. Oxford: CEBM; 2011 [accessed on Mar 20, 2021]. Available at: https://www.cebm.ox.ac.uk/resources/levels-of-evidence/ocebm-levels-of-evidence

17. Claudio CV, Ribeiro RP, Martins JT, Marziale MHP, Solci MC, Dalmas JC. Hidrocarbonetos policíclicos aromáticos produzidos pela fumaça do eletrocautério e uso de equipamentos de proteção individual. Rev Lat Am Enfermagem. 2017;25:e2853. https://doi.org/10.1590/1518-8345.1561.2853

18. Hu X, Zhou Q, Yu J, Wang J, Tu Q, Zhu X. Prevalence of HPV infections in surgical smoke exposed gynecologists. Int Arch Occup Environ Health. 2021;94(1):107-15. https://doi.org/10.1007/s00420-020-01568-9

19. Michaelis M, Hofmann FM, Nienhaus A, Eickmann U. Surgical smoke-hazard perceptions and protective measures in german operating rooms. Int J Environ Res Public Health. 2020;17(2):515. https://doi.org/10.3390/ijerph17020515

20. Weld KJ, Dryer S, Ames CD, Cho K, Hogan C, Lee M, et al. Analysis of surgical smoke produced by various energy-based instruments and effect on laparoscopic visibility. J Endourol. 2007;21(3):347-51. https://doi.org/10.1089/end.2006.9994

21. Associação Brasileira de Enfermeiros de Centro Cirúrgico, Recuperação Anestésica e Centro de Material e Esterilização (SOBECC). Diretrizes de práticas em enfermagem cirúrgica e processamento de produtos para a saúde. 7ª ed. São Paulo: SOBECC; Barueri: Manole; 2017.