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RESEARCH ARTICLE (ORIGINAL)

Analysis of the incidence of signs and symptoms associated with occupational exposure to surgical smoke in residents

Análise da incidência de sinais e sintomas relacionados à exposição ocupacional ao fumo cirúrgico na residência

Análisis de la incidencia de signos y síntomas relacionados con la exposición laboral al humo quirúrgico en la residência

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Abstract
Background: Medical residents in operating rooms present signs and symptoms associated with occupational exposure to surgical smoke.
Objective: To determine the incidence and relative risk of developing signs and symptoms associated with surgical smoke exposure in medical residents.
Methodology: A cohort study was conducted with medical residents exposed and unexposed to surgical smoke. Data collection was conducted in two moments, over four months, using a questionnaire containing items on sociodemographic and occupational characteristics and surgical smoke-related signs and symptoms and protective measures.
Results: The most frequent signs and symptoms in those exposed compared to those unexposed to surgical smoke were foreign body sensation in the throat, burning sensation in the pharynx, irritation of other mucous membranes, and nasopharyngeal lesions. The use of protective eyewear was a protective factor for those exposed (p = 0.01).
Conclusion: Surgical smoke-related signs and symptoms are higher in medical residents exposed than in those unexposed. The relative risk of developing signs and symptoms is always higher for those exposed.

Keywords: surgical smoke; signs and symptoms; occupational exposure; air pollutants, occupational; occupational health

Resumo
Enquadramento: Os médicos residentes das salas operatórias apresentam sinais e sintomas relacionados à exposição ao fumo cirúrgico.
Objetivo: Determinar a incidência e o risco relativo do desenvolvimento de sinais e sintomas relacionados com a exposição ao fumo cirúrgico em médicos residentes.
Metodologia: Estudo de coorte, realizado com médicos residentes expostos e não expostos ao fumo cirúrgico. A colheita de dados foi realizada em dois momentos, durante quatro meses, com um formulário contendo as características sociodemográficas, de trabalho, sinais e sintomas e medidas preventivas.
Resultados: Os sinais e sintomas mais incidentes nos expostos quando comparados com os não expostos ao fumo cirúrgico foram sensação de corpo estranho na garganta, ardência de faringe, irritação de outras mucosas e lesões nasofaríngeas. A utilização dos óculos de proteção foi um fator de proteção para os expostos (p = 0,01).
Conclusão: Houve maior incidência de sinais e sintomas relacionados com o fumo cirúrgico nos expostos quando comparados aos não expostos. O risco relativo de desenvolvimento de sinais e sintomas é sempre maior para os expostos.

Palavras-chave: fumo cirúrgico; sinais e sintomas; exposição ocupacional; poluentes ocupacionais do ar; saúde do trabalhador

Resumen
Marco contextual: Los médicos residentes de los quirófanos presentan signos y síntomas relacionados con la exposición al humo quirúrgico.
Objetivo: Determinar la incidencia y el riesgo relativo de desarrollar signos y síntomas relacionados con la exposición al humo quirúrgico en médicos residentes.
Metodología: Estudio de cohorte, realizado con médicos residentes expuestos y no expuestos al humo quirúrgico. La recogida de datos se realizó en dos momentos, durante cuatro meses, con un formulario que contenía las características sociodemográficas y laborales, los signos y los síntomas, y las medidas preventivas.
Resultados: Los signos y síntomas más incidentes en aquellos expuestos en comparación con los no expuestos al humo quirúrgico fueron sensación de cuerpo extraño en la garganta, ardor faríngeo, irritación de otras mucosas y lesiones nasofaríngeas. El uso de gafas protectoras fue un factor de protección para los expuestos (p = 0,01).
Conclusión: Hubo una mayor incidencia de signos y síntomas relacionados con el humo quirúrgico en aquellos expuestos en comparación con los no expuestos. El riesgo relativo de desarrollar signos y síntomas es siempre mayor para los expuestos.

Palabras clave: humo quirúrgico; signos y síntomas; exposición profesional; contaminantes ocupacionales del aire; salud laboral

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Introduction

Electrocautery is a surgical procedure for precise tissue ablation and localized hemostatic control (Mittelstein et al., 2017). Despite being widely used, it presents some risks to surgical patients and surgical teams. Apart from the risk of thermal burns, this procedure produces surgical smoke, exposing surgical patients and surgical teams in the operating rooms (OR) to the chemicals in the smoke's composition (Georgesen & Lipner, 2018).

Surgical smoke, described as an occupational air pollutant, is made of particulate matter composed of cellular fragments, viruses, and blood particles, and gases containing chemical compounds such as polycyclic aromatic hydrocarbons (PAHs; Claudio et al., 2017; Tan & Russel, 2017), volatile organic compounds (VOCs; Swerdlow, 2020) and carbon monoxide (CO; Limchantra et al., 2019). These chemical compounds are responsible for the mutagenic and carcinogenic effects caused by surgical smoke exposure (Georgesen & Lipner, 2018).

Health professionals exposed to surgical smoke can present the following signs, symptoms, and diseases: eye irritation and lacrimation; coughing; acute and chronic inflammatory changes in the respiratory tract; sneezing; headaches; nausea; vomiting; fatigue; hypoxia; cardiovascular dysfunction; cancer; hepatitis (Alp et al., 2006; Navarro-Meza et al., 2013); foreign body sensation in the throat; nasal congestion; burning sensation in the pharynx; weakness; dizziness; pulmonary emphysema; asthma and bronchitis (Ilce et al., 2016); and histopathological changes in the nasal mucosa (hyperplasia or squamous metaplasia) diagnosed after biopsy (Navarro et al., 2016).

Considering health professionals' signs and symptoms when exposed to surgical smoke, using protective measures whenever exposed to this risk is recommended. These protective measures can be individual, such as the use of N95/PFF2 masks and protective eyewear (Association of Perioperative Registered Nurses [AORN], 2017), or collective, such as local exhaust ventilation equipment or vacuum pumps with filters and adequate ventilation of the OR (AORN, 2017; Occupational Safety and Health Administration, 2015).

However, reality differs from recommendations. In their practice, surgical teams use standard surgical masks without protective eyewear, and the OR have no collective protective equipment.

Some studies' results already demonstrate the harmful effects of surgical smoke on the health of those exposed to this occupational air pollutant. However, these are still incipient, and health managers and professionals cannot use them to ground their decision-making regarding occupational health care. Also, it is necessary to define the exposure time needed to develop the signs and symptoms that signal the need for more care before the onset of occupational diseases associated with surgical smoke exposure.

Hence, the present study aims to determine the incidence and relative risk of developing signs and symptoms associated with surgical smoke exposure in medical residents.

Background

Considering the harmful effects that surgical smoke can cause on health professionals' health, Alp et al. (2006) conducted a literature review on the signs and symptoms and acute and chronic diseases associated with this occupational risk. The study found that health professionals exposed to surgical smoke throughout their professional career can develop signs and symptoms such as eye irritation, nausea and vomiting, headaches, dizziness, sneezing, weakness, dermatitis, cancer, and asthma and bronchitis.

A Mexican study by Navarro-Meza et al. (2013) aimed to determine the frequency of surgical smoke-related symptoms in residents of different surgical specialties. Navarro-Meza et al. observed that residents experienced nausea (4%), as previously described, but also presented some new signs and symptoms, such as foreign body sensation in the throat (58%), burning sensation in the pharynx (22%), and nasal congestion (2%).

Ünver et al. (2016) found in a study conducted with 54 Turkish perioperative nurses the following surgical smoke-related symptoms: headaches; pharynx irritation; nausea; lacrimation; weakness; and dizziness.

Ilce et al. (2016) observed in doctors and nurses exposed to surgical smoke signs and symptoms, such as headaches, lacrimation, coughing, burning sensation in the pharynx, nausea, drowsiness, weakness, nasopharyngeal lesions, vomiting, and the absorption of surgical smoke odors into the hair. A descriptive study conducted by Okgün Alcan et al. (2017) with nurses in Turkey also observed the following signs and symptoms associated with surgical smoke: headaches; nausea; coughing; burning sensation in the pharynx; lacrimation; sneezing; dizziness; irritability; weakness; nasopharyngeal lesions; vomiting; abdominal pain; and cramping.

In Thailand, Asdornwised et al. (2018) conducted a survey-type study with perioperative nurses and determined that the most common symptoms associated with surgical smoke exposure were: headaches; throat irritation; coughing, sneezing, weakness, eye irritation, nausea, and dizziness.

Finally, a descriptive study conducted by Usta et al. (2019) in four hospitals with nurses exposed to surgical smoke demonstrated a prevalence of symptoms, such as headaches, nausea, vomiting, coughing, irritation in the pharynx, irritability, dizziness, nasopharyngeal lesions, weakness, cramping, and abdominal pain.

Research question

Do medical residents exposed to surgical smoke have a higher incidence and relative risk of developing surgical smoke-related signs and symptoms than those unexposed to surgical smoke?

Methodology

This quantitative longitudinal cohort study was conducted in two Brazilian hospitals in northern Paraná, designated as I and II. Hospital I is a teaching hospital

with high-complexity care, 300 beds, and a mean of 18 surgeries per day. Hospital II is a philanthropic hospital with high-complexity care, 335 beds, and a mean of 19 surgeries per day.

The sample was formed with 84 medical residents from the surgical units, clinical specialties, and anesthesiology unit of Hospital I and 26 medical residents of the surgical units, clinical specialties, and anesthesiology unit of Hospital II. All participants began their residency in 2018.

The inclusion criterion for the group of exposed medical residents was to be a medical resident exposed to surgical smoke during work attending medical residency programs in the surgical units (general surgery, pediatric surgery, vascular surgery, dermatology, neurosurgery, obstetrics and gynecology, orthopedics, otorhinolaryngology, and urology), the anesthesiology unit, and the clinical specialties of pediatrics and neonatology. Despite being from clinical specialties, medical residents in pediatrics and neonatology are also exposed to surgical smoke during work, for example, when they receive neonates in the OR. Therefore, 60 medical residents were considered eligible for the group of those exposed to surgical smoke (experimental group).

The inclusion criterion for the group of medical residents unexposed to surgical smoke (control group) was to be a medical resident unexposed to surgical smoke during work attending medical residency programs in one of the following clinical specialties: clinical medicine; rheumatology; gastroenterology; pulmonology; psychiatry; cardiology; neurology; adult intensive care medicine; pediatric intensive care medicine; infectious diseases; pediatric infectious diseases; pathology and endocrinology and metabolism. The unexposed medical residents were included in this study because they are needed to calculate the prevalence ratio. Therefore, 50 medical residents were considered eligible for the group of those unexposed to surgical smoke.

Medical residents on holiday during the first or second moment of data collection and those who did not participate in the second moment of data collection were excluded from the sample.

A sample calculation was performed using the Epi Info™ software, which determined a sample size of 39 residents in each group (exposed and unexposed). Considering that a percentage of 20% of possible participant losses is common in longitudinal studies and that the present study's total eligible sample was larger than determined by the sample calculation, the investigators chose to use all eligible medical residents.

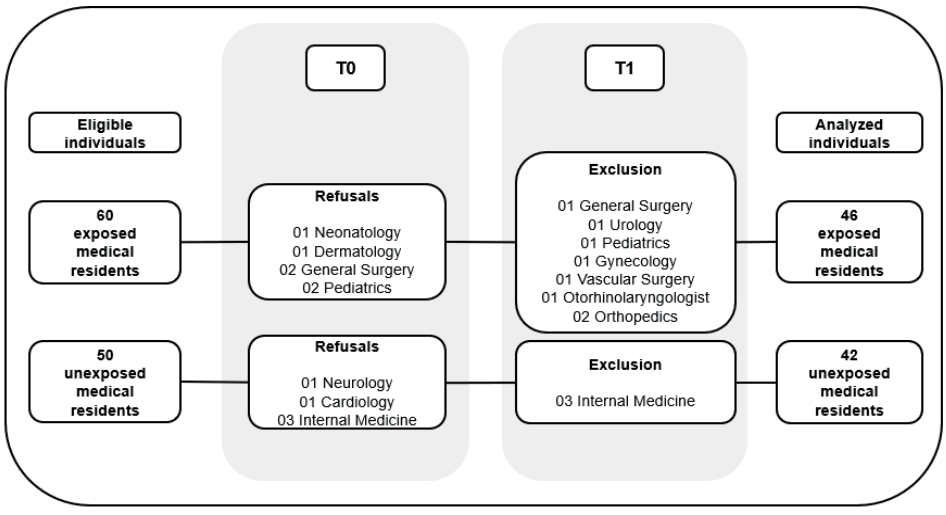
Data began to be collected with the medical residents exposed and unexposed to surgical smoke in March 2018. This first moment of data collection was designated as T0 and considered the baseline for analyzing the signs and symptoms in the exposed and unexposed groups. Once the study's objectives were presented, data collection in T0 aimed to characterize the study's sample and verify the presence of signs and symptoms associated with surgical smoke exposure before surgical smoke exposure began.

The second data collection moment, designated as T1, was conducted in June 2018, corresponding to the medical residents' fourth month of residency. It aimed to verify the presence of signs and symptoms associated with surgical smoke exposure after being exposed or not to surgical smoke.

The inclusion, exclusion, and refusal of medical residents during data collection are explained in Figure 1. It presents the population eligible for data collection among medical residents exposed and unexposed to surgical smoke.

Figure 1

Inclusion, exclusion, and refusal of medical residents during T0 and T1 of data collection



The data collection questionnaires were evaluated by perioperative care and/or occupational health experts. The experts assessed the clarity, understanding, and presentation of the questionnaire's items and the comprehensiveness and representativeness of their content.

The investigators invited the experts through a summary

containing the present study's presentation, its objectives and methodology, and the type of assessment expected from them. An Informed Consent Form (ICF) was sent to the experts regarding their participation in the questionnaire's assessment. After receiving the experts' invitation acceptance and ICFs, the investigators sent the data collection questionnaire for assessment. After analyzing the experts' suggestions, the investigators considered it necessary to alter the questionnaire's structure and content. The final questionnaire included three forms. The first form focused on the medical residents' sociodemographic characterization and description of life habits and pre-existing diseases. It was applied only in the first data collection moment (T0). The second form aimed to characterize the medical residents' work, including the weekly periods (morning, afternoon, and evening) spent in the OR, the weekly hours spent performing surgical procedures, and the number of surgeries they participated in during the previous month. It was applied in the exposed group in T0 and T1. In T1, medical residents were also asked about the number of procedures they participated in over the previous three months. The third form presented items on the signs and symptoms associated with surgical smoke exposure, such as foreign body sensation in the throat, burning sensation in the pharynx, nausea and vomiting, nasal congestion, headaches, eye irritation, other mucous membranes irritation (nose and mouth), sneezing, weakness, dizziness, lacrimation, and nasopharyngeal lesions (Ilce et al., 2016, Navarro et al., 2016, Navarro-Meza et al., 2013). Items on the use of recommended protective measures, such as surgical masks, N95/PFF2 masks, protective eyewear, and specific exhaust ventilation equipment for surgical smoke used by medical residents during their work whenever there was a risk of exposure, were also included. Medical residents could also use the third form to report other signs and/or symptoms not previously mentioned, not even in the literature. This form was used for data collection in both T0 and T1.

All questionnaire items were self-reported and regarded surgical smoke-related signs and symptoms and protective measures. The medical residents answered yes or no to the items and could present more than one sign and symptom per interval.

The descriptive analysis of the sociodemographic data was performed using absolute and relative frequencies. The absolute and relative frequencies of signs and symptoms reported by the medical residents were also assessed by calculating the incidence and using the Relative Risk (RR) and respective confidence intervals to measure association. The interpretation adopted was as follows: an RR of 1.0 indicated that there was no association between the risk factor and the outcome; an RR higher than 1.0 indicated that exposure was a risk factor, whereas a RR lower than 1.0 indicated that exposure could be considered a protection factor (Darski et al., 2021). McNemar's test compared the onset of signs and symptoms in the exposed group at T0 and T1. A Poisson regression assessed the interaction between protective measures (use of protective eyewear) and signs and symptoms. The inferential analysis of the outcomes linked to surgical smoke exposure was assessed using the Chi-square test. A 5% significance level was considered. The data were inserted into tables and analyzed using the Statistical Products and Service Solutions - SPSS® software, version 20.0.

The present study met the ethical criteria for studies involving human beings approved by the Ethics Committees of the two hospitals where data collection was conducted. It was approved under the Certificates of Presentation for Ethical Consideration (CAAE) number: 46229915.0.0000.5231 and 46229915.0.3001.0099.

Results

The present study had a sample of 46 medical residents exposed to surgical smoke in their work and 42 medical residents unexposed to surgical smoke in their work from two hospitals.

The participants in the exposed group were primarily women (54.3%), with a mean age of 27 years (*SD*: 2.657); 78.7% had graduated in the previous two years and were from the following specialties: general surgery (23.9%); pediatrics (17.3%); anesthesiology (15.2%); gynecology and obstetrics (15.2%); orthopedics (8.6%); neurosurgery (4.4%); neonatology (4.4%); vascular surgery (4.4%); pediatric surgery (2.2%); otorhinolaryngology (2.2%); and dermatology (2.2%). The mean number of surgeries performed in the first month was 25 (*SD*: 25.61) surgeries per medical resident and 34 (*SD*: 33.41) surgeries per medical resident in the fourth month.

The participants in the unexposed group were primarily men (66.7%), with a mean age of 27 years (*SD*: 3.268); 45.2% had graduated in the previous two years and were from the following specialties: clinical medicine (38%); rheumatology (4.8%); gastroenterology (7.1%); pulmonology (4.8%); psychiatry (7.1%); cardiology (7.1%); neurology (7.1%); adult intensive care medicine (4.8%); pediatric intensive care medicine (4.8%); infectious diseases (4.8%); pediatric infectious diseases (2.4%); pathology (2.4%) and endocrinology and metabolism (4.8%).

Table 1 shows the incidence of signs and symptoms presented by medical residents exposed and unexposed to surgical smoke at T1 (fourth month of residency).

Table 1

Incidence of signs and symptoms presented by medical residents exposed and unexposed to surgical smoke in the fourth month of residency (T1)

Signs and symptoms	Exposed *N* = 46 (100%)	Unexposed *N* = 42 (100%)	RR (confidence interval)	*p* value**
Foreign body sensation in the throat	8 (17.4)	3 (7.1)	2.73 (0.67 –11.09)	0.14
Burning sensation in the pharynx	7 (15.2)	2 (4.8)	3.5 (0.70 – 18.36)	0.10
Nausea	3 (6.5)	3 (7.1)	0.90 (0.17 – 4.76)	0.90
Nasal congestion	15 (32.6)	20 (47.6)	0.53 (0.22 – 1.26)	0.15
Headache	8 (17.4)	13 (31.0)	0.47 (0.17 – 1.28)	0.13
Eye irritation	5 (10.9)	5 (11.5)	0.90 (0.24 – 3.36)	0.87
Other mucous membranes* irritation	7 (15.2)	2 (4.8)	3.59 (0.70 – 18.36)	0.10
Sneezing	9 (19.6)	13 (31.0)	0.54 (0.20 – 1.44)	0.21
Weakness	4 (8.7)	4 (9.5)	0.90 (0.21 – 3.87)	0.89
Dizziness	3 (6.5)	2 (4.8)	1.39 (0.22 – 8.78)	0.72
Lacrimation	5 (10.9)	4 (9.5)	1.15 (0. 28 – 4.63)	0.83
Nasopharyngeal lesions	4 (8.7)	2 (4.8)	1.90 (0.33 – 10.98)	0.46

Note. RR = Relative risk.
*Mouth and nose; **Chi-square ($p < .05$).

Table 2 compares the signs and symptoms reported by the exposed group at T0 and T1.

Table 2

Comparison of the signs and symptoms presented by the exposed group during T0 (first month) and T1 (fourth month) of residency

Signs and symptoms	T0 (1st month)	T1 (4th month)	*p* value**
Foreign body sensation in the throat	4 (50%)	4 (50%)	0.12
Burning sensation in the pharynx	-	7 (100%)	-
Nausea, vomiting	2 (66.7 %)	1 (33.3%)	1.00
Nasal congestion	5 (33.3%)	10 (66.7%)	0.45
Headache	5 (62.5%)	3 (37.5%)	1.0
Eye irritation	2 (40%)	3 (60%)	1.0
Other mucous membranes* irritation	5 (71.4%)	2 (28.6%)	0.21
Sneezing	4 (44.4%)	5 (55.6%)	1.0
Weakness	1 (25%)	3 (75%)	1.0
Dizziness	2 (66.7%)	1 (33.3%)	1.0
Lacrimation	3 (60%)	2 (40%)	0.72
Nasopharyngeal lesions	-	4 (100%)	-

*mouth and nose **McNemar ($p < .05$).

The recommended protective measures - N95 masks and specific exhaust ventilation equipment for surgical smoke - were not used and did not protect the medical residents exposed to surgical smoke.

Table 3 shows the effect of protective eyewear on signs and symptoms presented by medical residents exposed to surgical smoke during T1 (fourth month of residency).

Table 3

The effect of protective eyewear on signs and symptoms presented by medical residents exposed to surgical smoke during T1 (fourth month of residency) Paraná- Brazil, 2018 (n = 46)

Variables	B Coefficient	95% CI	*p* value
Signs and symptoms	0.480	0.273 – 0.845	0.01*

*Poisson regression; Dependent Variable: use of protective eyewear - Model: (Intercept) having signs and symptoms.

Discussion

During the studied period, there is no evidence of the association between surgical smoke exposure and the development of signs and symptoms in exposed medical residents. Nevertheless, when comparing exposed to unexposed medical residents, the signs and symptoms with the highest incidence are foreign body sensation in the throat, burning sensation in the pharynx, other mucous membranes irritation, and nasopharyngeal lesions. In the present study, the mean number of surgeries in T0 is 25 per resident per month and 34 per resident per month in T1. Even though Navarro et al.'s study (2016) presented a higher exposure level, with a mean number of 89.6 surgeries per month, the present study's medical residents present more surgical smoke-related signs and symptoms after extended periods of occupational exposure. Thus, the incidence of signs and symptoms is directly proportional to the number of surgeries per month. Also, it is worth noting that the effects on the exposed individuals' bodies are cumulative (Ilce et al., 2016), making these medical residents more susceptible to developing diseases.

The prevalence of the symptoms of foreign body sensation in the throat, burning sensation in the pharynx, and nausea/ vomiting demonstrated by Navarro et al. (2016) coincide with the incidence in the present study. This can be associated with the number of smoke particles the health professionals' respiratory tract retains, considering this is the first area exposed to surgical smoke (Ilce et al., 2016).

Cauterized tissues produce different amounts of particulate matter. For example, the liver produces the largest amounts of particulate matter, so interventions performed on the liver present higher risks to surgical teams regarding surgical smoke exposure. Skeletal muscle and renal tissues produce a medium mass of particulate matter. Skin, cerebral gray and white matter, subcutaneous fat, and lungs produce few particles (Karjalainen et al., 2018), exposing health professionals to lower yet existing risks.

The chemical composition of surgical smoke influences the development of the most reported symptoms in the present study. For example, short-term exposure to the acetaldehyde present in surgical smoke can irritate the skin, eyes, and respiratory tract, and short-term exposure to benzene, also present in surgical smoke, can lead to headaches, dizziness, nausea, and irritation in the eyes and other mucous membranes (Okoshi et al., 2015).

Headaches are the symptom most frequently reported by nurses and doctors exposed to surgical smoke in the OR, accompanied by other symptoms such as eye burning, coughing, throat irritation, and nausea (Navarro-Meza et al., 2013).

Using Personal Protective Equipment (PPE) and Collective Protective Equipment (CPE; AORN, 2017; Occupational Safety and Health Administration, 2015) is recommended to protect health professionals from the risks of surgical smoke. However, in the two hospitals where the present study was conducted, there is no CPE in the OR to ensure adequate ventilation of the environment, and local exhaust ventilation equipment for surgical smoke is unavailable.

Surgical smoke exhausters and adequate air ventilation reduce health professionals' exposure to chemical and biological compounds generated by tissue cauterization. Therefore, filters must be controlled and replaced frequently to avoid releasing harmful materials into the air (Limchantra et al., 2019).

Regarding PPE, none of the residents in the present study uses N95/PFF2 masks to protect against surgical smoke harm. These masks filter 95% of the airborne pollutant particles in the OR. They are efficient on particles up to 0.3 microns (Georgesen & Lipner, 2018), as is the case of the particulate matter in surgical smoke, which ranges from > 0.07 microns to 6.5 microns (Tan & Russell, 2017).

Even with studies demonstrating how harmful surgical smoke exposure is, nurses exposed to this occupational risk do not wear N95/PFF2 masks in their practice. The nursing professionals participating in the qualitative study conducted by Netto et al. (2021) reported that using this PPE caused discomfort and shortness of breath, apart from injuring their faces.

In addition to masks, using individual protective eyewear is also recommended during occupational exposure to surgical smoke (AORN, 2017). This protective measure can prevent the appearance of eye-related signs and symptoms, such as eye irritation and lacrimation reported in the present study.

The sample size of medical residents exposed and unexposed to surgical smoke and the lack of data collection regarding the medical residents' length of stay in surgery are considered limitations of the present study. Also, considering the studies already conducted on this topic, it is still impossible to affirm that the signs and symptoms presented in the literature are specific to this type of exposure, as they are also caused by other common diseases in this population. Nevertheless, the present study considers that occupational exposure to surgical smoke must not be disregarded.

Conclusion

When comparing the groups exposed and unexposed to surgical smoke, no significant association is observed between the medical residents and the signs and symptoms in the fourth month of exposure. The most frequently reported signs and symptoms are foreign body sensation in the throat, burning sensation in the pharynx, irritation of other mucous membranes (mouth and nose), and nasopharyngeal lesions. Nonetheless, the relative risk for developing signs and symptoms is always higher in those exposed.

Longitudinal studies with more extended study periods of the individuals exposed to surgical smoke are needed to assess the time of development of signs and symptoms and the risk over time of exposed individuals, considering that the harm caused by surgical smoke is cumulative.

Moreover, health professionals must be aware of the need for adequate PPE. Health institution managers must provide their staff with PPE, respect the need to use it and install CPE in the OR to reduce health professionals' exposure to the risks of surgical smoke.

Therefore, all health professionals exposed to surgical smoke during work must use N95/PFF2 masks and protective eyewear to avoid developing the signs and symptoms preceding the onset of chronic diseases. Also, health researchers should invest in developing PPE that ensures the safety and comfort of the health professionals wearing them.

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