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ORIGINAL ARTICLE

USE OF THE N95 MASK BY NURSING WORKERS EXPOSED TO SURGICAL SMOKE

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ABSTRACT

Objective: to check the discomfort presented by workers who need to use the N95 mask during their work activities. **Method:** descriptive and cross-sectional research, developed in the Surgical Center of a teaching hospital located in Southern Brazil, from June to August 2019, during the daytime work shift. The study was conducted with nursing professionals who were exposed to surgical smoke during their work period. In order to collect data, an instrument was used with sociodemographic and occupational details of the participants and a N95 mask was given to professionals to be used during surgery, in order to check the time of use of the N95 and the reasons why the workers removed the mask during the anesthetic-surgical procedure. **Results:** the largest number of workers (27.7%) used the mask for up to 3 hours during the anesthetic-surgical procedure, and this time was related to some complaints (p=0.037), such as discomfort (27.8%), tightness (44.4%) and nausea (5.6%). The removal of the N95 mask (p=0.022) by these professionals before the end of the surgery was related to these complaints. **Conclusion:** workers have complaints such as discomfort, tight mask and nausea, and these are related to the time of use, which needs to be assessed by managers for the use of N95.

Keywords: Respiratory Protective Devices. Personal Protective Equipment. Air Pollutants. Occupational. Health Personnel. Occupational Health Nursing.

INTRODUCTION

Workers in the Surgical Center (SC) are vulnerable to various occupational risks, which can lead them to illness throughout their professional career. As examples of the occupational risks present in this work unit, one can mention the substances present in the surgical smoke generated when electrocautery is used[1].

Electrocautery, a technology widely used in SC to perform incisions, coagulation and tissue dissection, releases chemical compounds in the form of gas (gas phase) and particles (particulate phase), the surgical smoke, which has a characteristic odor and is capable of developing diseases and signs and symptoms in the surgical team workers who are exposed, constituting an occupational risk to these professionals[2-4].

Among the chemicals found in surgical smoke, one can mention the Polycyclic Aromatic Hydrocarbons (PAH), Volatile Organic Compounds (VOC) and Carbon Monoxide (CO, chemical formula). These compounds have mutagenic and carcinogenic effects and can be retained in the respiratory tract when inhaled[2,4]. Workers can manifest the following signs and symptoms: headache; foreign body sensation in the throat; pharyngeal burning; nausea; vomiting; irritation of the eyes and other mucous membranes, such as the mouth and nose[5-6].

Therefore, in order to prevent surgical smoke inhalation, there are measures recommended by the *Association of periOperative Registered Nurses* (AORN) to be adopted, such as the use of Collective Protection Equipment (CPE): surgical smoke evacuators and exhaust fans installed in operating rooms. There is also the

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Personal Protective Equipment (PPE), such as N95/PFF2 breathing mask during surgical procedures[7].

This type of mask refers to a respirator with a filter capable of filtering 95% of the airborne particles. It is a type of mask that has undergone certification testing to ensure adequate particle filtration performance and must be worn covering the nose and mouth, allowing full face fit. This reduces the risk of inhaling hazardous airborne particles smaller than $1\mu m$, i.e. with a mean air mass diameter of $300nm$. The use of the N95/PFF2 mask is recommended to reduce the risks of exposure to surgical smoke inside operating rooms[1,8].

There is also the common surgical mask, a face mask used to protect the surgical patient and perioperative team members from contamination by microorganisms and body fluids. This type of mask is used to protect workers from contact with infectious droplets > 5 micrometers in size[1].

In everyday life, the most commonly used mask in SC is the simple surgical mask. This is not considered respiratory protection, as it is a loose mask designed with the purpose of reducing the spread of bio-aerosol from the user to the environment, rather than protecting the user from inhaling environmental aerosols[9]. Because it is looser and does not fully fit the user's face, it is considered a more comfortable mask for daily use when compared to the N95/PFF2.

The discomfort caused by the use of the N95/PFF2 mask is one of the reasons mentioned by workers for not using this type of mask during the daily work hours[10]. In addition, workers are unaware of the need to use the N95/PFF2 mask when exposed to surgical smoke inhalation. Accordingly, it is necessary to know the discomfort that these workers have with this type of mask so that actions can be implemented to improve the technologies used in the manufacture of PPE.

Given the above, one can ask the following research question: what are the discomforts presented by workers who use the N95/PFF2 mask during their work activities? Therefore, the objective of this research was to check the discomforts presented by workers who need to use the N95/PFF2 mask during their work activities.

METHOD

This is a descriptive research with cross-sectional design, developed in the SC of a teaching hospital located in the South region of Brazil, in the period from June to August 2019, during the daytime work shift.

This SC is composed of seven operating rooms, three of which are medium-sized, measuring 34.22m^2, and the others are large, measuring 32.78m^2. All rooms have two doors, one for the entrance of the surgical team and the other for the entrance and exit of patients and equipment, and do not have exhausters or air fresheners, with two points for common air conditioning.

The SC is composed of 1 team with 39 employees, during daytime and nighttime. Of these, 18 workers, including nurses, technicians and nursing assistants who agreed to wear the N95 mask during the surgery for which they were scheduled and surgical smoke exposure occurred, were included in the study.On the other hand, workers who were on leave and vacation during the collection period were excluded.

In order to collect data, an instrument developed by the researchers was used, containing sociodemographic and occupational details of the participants with the following data: age; gender; professional relationship; duration of time in the profession; education; duration of surgery; duration of time using the N95 mask; and discomforts related to the use of the N95 mask.

The research was conducted with the workers at the beginning of their shift, with instructions about the research objective. Those who agreed to participate were given a N95 mask and instructed that they should wear the mask for the entire duration of the surgery, but that they could remove it at any time and exchange it for the simple surgical mask, if they so wished, since there is no determination for the use of this PPE in relation to protection against surgical smoke inhalation in the hospital at stake.

The time of use of the N95 mask was recorded by the researcher from the moment the worker put the mask on and entered the operating room until the moment he/she removed the mask. The stopwatch was also

paused during the time the worker left the operating room (since they usually remove their masks at this time), as well as the number of times the N95 mask was removed during the anesthetic-surgical procedure to which the worker was assigned. The questions contained in the data collection instrument were asked to the included workers at the end of the surgery.

The data were analyzed using the software named *Statistical Products and Service Solutions* – SPSS® (version 20.0). In the inferential analysis, the chi-square test was used and a 5% significance level was adopted.

This research was approved by the Ethics Committee for research involving human beings with CAAE 46229915.0.0000.5231. The workers who participated in the research signed the Free and Informed Consent Form.

RESULTS

The study had the participation of 18 (75%) nursing workers, 12 (66.6%) of whom were nursing technicians, 4 (22.2%) nursing assistants and 2 (11.1%) nurses, with a mean time working in nursing of 16.8 years.

Of the workers who participated in the survey, 2 (11.1%) stayed with the N95 mask for the entire surgery time and 5 (27.7%) stayed with the N95 mask for more than half of the surgery time, as shown in Table 1.

Table 1. Relationship between the time of use of the N95 mask by workers exposed to surgical smoke (n=18) and the duration of the anesthetic-surgical procedure. Londrina, PR, Brazil, 2019

Use of the N95 mask	Duration of the anesthetic-surgical procedure					Total
	1 hour	1 - 2h	2 - 3h	3 - 4h	More than 4 hours	
Up to 1h	1	3	4	0	1	9
1h01- 2h	0	3	0	0	1	4
2h01- 3h	0	0	3	0	0	3
3h01- 4h	0	0	0	2	0	2
+4h01	0	0	0	0	0	0
Total	**1**	**6**	**7**	**2**	**2**	**18**

Regarding the time of use of the N95 mask, the greatest number of employees used the mask up to 3 hours during the anesthetic-surgical procedure, and this time was related to some discomforts presented by workers (p=0.037), as shown in Table 2.

Table2. Relationship between the time of use of the N95 mask during the anesthetic-surgical procedure and the main discomforts reported by workers exposed to surgical smoke (n=18). Londrina, PR, Brazil, 2019

Time of use of the N95 mask	Main discomforts								p-value
	Uncomfortable		Tightness		Nausea		Without complaints		
	n	%	n	%	n	%	n	%	
1h	1	(5,6)	3	(16,6)	1	(5,6)	0	0	
1h01– 2h	0	0	4	(22,2)	0	0	0	0	
2h01 – 3h	2	(11,1)	0	0	0	0	2	(11,1)	
3h01 – 4h	2	(11,1)	1	(5,6)	0	0	2	(11,1)	
Total	**5**	**(27,8)**	**8**	**(44,4)**	**1**	**(5,6)**	**4**	**(22,2)**	**0,037**

Chi-Square Test - significance level p<0.05

The discomforts reported by workers who used the N95 mask during surgery and the removal of the N95 mask before the end of the surgery were significant among themselves (p=0.022), as shown in Table 3.

Table 3. Relationship between the removal of the N95 mask during surgery and discomforts reported by workers exposed to surgical smoke (n=18). Londrina, PR, Brazil, 2019

Removal of the N95 mask	Main discomforts								p-value
	Uncomfortable		Tightness		Nausea		Without complaints		
	n	%	n	%	n	%	n	%	
Sim	2	(11,1)	7	(38,9)	1	(5,5)	0	0	
Não	3	(16,6)	1	(5,6)	0	0	4	(22,2)	
Total	**5**	**(27,7)**	**8**	**(44,5)**	**1**	**(5,6)**	**4**	**(22,2)**	**0,022**

Chi-Square Test - significance level p<0.05

When the workers were asked if they would use the N95 mask, if required, whenever they were exposed to surgical smoke, 5 of them (27.7%) would use it because of the greater safety that the mask provides. Those who would not use the mask (72.22%) mentioned as the main reasons: being tight, uncomfortable, stuffy and causing shortness of breath. Of the participants, 83.3% reported that they would improve the mask to be used, making it less tight, lighter and ventilated.

DISCUSSION

The Association of PeriOperative Registered Nurses (AORN) recommends the use of measures to reduce the exposure of professionals to surgical smoke. Among these measures, one can mention the use of N95 mask by workers during surgeries that use electrocautery and, therefore, have the formation of surgical smoke[7]. Respiratory protection with the use of N95 masks as PPE is a way to reduce the inhalation of chemical compounds released by surgical smoke, for example, Polycyclic Aromatic Hydrocarbons (PAH).

In SC, electrocautery is used a lot during surgeries, with the release of products that are harmful to the health of exposed individuals, regardless of how long this equipment has been used. The surgical smoke contains chemical compounds such as PAH, which are suspended in the air of the operating room, being a chemical risk to workers exposed to these compounds, since they are cumulative in the human body, and may cause late deleterious effects to the health of these workers[11].

In a recent study, chemical compounds were found in surgical smoke, such as PAH compounds and nitriles, including formaldehyde and benzene[12]. These compounds have carcinogenic and mutagenic effects, and that is why the International Agency for Research on Cancer (IARC) considers that there is no safe dose for exposure to this substance and establishes that it should be 100% avoided[13-14]. Therefore, the only form of protection for exposed workers is the use of PPE and CPE.

Prolonged and chronic exposure to chemicals in surgical smoke has shown acute and chronic inflammatory changes in the respiratory system and contributes to an increased risk of cardiovascular diseases[3]. However, research has shown that the respiratory system of both the surgical team and the exposed patients may be more affected than the other systems, because the particle size of these compounds present in the surgical smoke is considered aerosolized, and these particles can penetrate the lung alveoli[1,5].

In order to prevent the disease of workers exposed to the inhalation of this smoke, it is necessary to combine the use of PPE and CPE. The surgical smoke evacuators are examples of CPE, together with the use of PPE, which in this case is the N95/PFF2 mask, but this is most commonly used during anesthetic-surgical procedures. The surgical mask does not adequately protect workers exposed to these compounds[15].

Nevertheless, the N95/PFF2 mask provides a high degree of protection to the user, since it is a filtering-type respirator for individual use, to be worn on the face, sealing the entire nose and mouth, thus reducing the risk that the user inhales hazardous particles that are suspended in the air. This mask, therefore, is a respiratory PPE[1,7].

Workers report discomfort when using the N95 mask. Therefore, this may be one of the

reasons for the low adherence to the use of this respiratory PPE[10]. Also in a study to check these discomforts, facial pain and pressure, heat and odor were found to be factors that cause discomfort when using the N95 mask during the prolonged work shift[16].

As in this study, symptoms of shortness of breath, dizziness, increased respiratory effort and headache have already been reported in another study, which found that measured physiological parameters such as heart rate, oxygen saturation and carbon dioxide concentration caused no clinically significant negative effects when using the N95 mask[17].

Despite the removal of the N95 mask during surgery by the surveyed workers, they recognize that the use of this mask is necessary for greater safety during some risky procedures to which they are exposed, and that they would use it in their work development if it were more comfortable to use. The correct use of PPE by the worker is indicated, since it is a measure of health protection during work activities and avoids the worker's exposure to contaminants existing in the workplace[17].

There are some factors that affect the acceptance by workers regarding the use of PPE, besides the comfort and ease of use, there is also the understanding of the need for its use[10]. In this study, the research participants mentioned that they use the N95 mask in risky procedures, but the risk procedures to which these workers referred are related to infectious diseases, highlighting their lack of knowledge about the chemical risk they are exposed to when using electrocautery.

Therefore, there is a need to adopt protection measures for workers who are in direct contact with surgical smoke, such as continuing education, in order to make the whole team aware of the risks that inhaling surgical smoke can cause to health and the importance of using the available equipment, as well as the adoption of PPE and CPE to protect these workers.

Another necessity is that the equipment used in the health area be ergonomically designed for the comfort and safety of workers. The presence of ergonomic risk factors, such as psychological, environmental and individual risks, can disturb the workers' comfort situation in the work environment and cause several aggravations, thus negatively affecting the work process[10].

This research is limited by the small sample of workers, determined by convenience, and also by the fact that it was conducted in a single hospital unit, thus not allowing the generalization of results. Despite the limitations, there is progress in relation to the discomfort of the professionals who need to use the N95 mask, which justifies further research for the development of a more comfortable and affordable respiratory PPE for workers and managers in relation to the cost of this equipment.

CONCLUSION

The exposed workers have complaints, such as discomfort, tightness in the face, as well as nausea, when using the N95 mask, and the time they use it during surgeries is related to these complaints. Most of the workers who had some type of discomfort removed the N95 mask before the end of the anesthetic-surgical procedure.

This study shows the need for investment in research with larger populations and investment for the development of PPE that better suits the workers, protecting them and causing them comfort in a safe and healthy work environment.

USO DA MÁSCARA N95 POR TRABALHADORES DE ENFERMAGEM EXPOSTOS À FUMAÇA CIRÚRGICA

RESUMO

Objetivo: verificar os desconfortos apresentados por trabalhadores que necessitam utilizar a máscara N95 durante as suas atividades laborais. **Método:** pesquisa descritiva com delineamento transversal, desenvolvida no Centro Cirúrgico de um hospital de ensino localizado na região Sul do Brasil, no período de junho a agosto de 2019, durante o turno de trabalho diurno. Realizou-se o estudo com os profissionais de enfermagem que estavam expostos à fumaça cirúrgica no período de trabalho. Para a coleta dos dados, utilizou-se um instrumento com detalhamento sociodemográfico e ocupacional dos participantes e entregou-se uma máscara N95 aos profissionais para ser utilizada durante a cirurgia, a fim deverificar o tempo de uso da N95 e os motivos pelos quais os trabalhadores retiraram a máscara durante o ato

anestésico-cirúrgico. **Resultados:** o maior número de trabalhadores (27,7%)utilizou a máscara até 3 horas durante o ato anestésico-cirúrgico, sendo que esse tempo foi relacionado com algumas queixas (p=0,037), tais como incômoda (27,8%), apertada (44,4%) e enjoo (5,6%). A retirada da máscara N95 (p=0,022) por esses profissionais antes do término da cirurgia foi relacionada a essas queixas. **Conclusão:** os trabalhadores apresentam queixas, como desconforto, máscara apertada e enjoo, sendo que estas estão relacionadas com o tempo de uso, o que precisa ser avaliado por gestores para a utilização da N95.

Palavras-chave: Dispositivos de Proteção Respiratória. Equipamento de Proteção Individual. Poluentes Ocupacionais do Ar. Pessoal de Saúde. Enfermagem do Trabalho.

USO DE LA MASCARILLA N95 POR TRABAJADORES DE ENFERMERÍA EXPUESTOS AL HUMO QUIRÚRGICO

RESUMEN

Objetivo: verificar las molestias presentadas por trabajadores que necesitan usar la mascarilla N95 durante sus actividades laborales. **Método**: investigación descriptiva con delineamiento transversal, desarrollada en el Centro Quirúrgico de un hospital de enseñanza ubicado en la región Sur de Brasil, en el período de junio a agosto de 2019, durante el turno de trabajo diurno. Se realizó el estudio con los profesionales de enfermería que estaban expuestos al humo quirúrgico en el período de trabajo. Para la recolección de los datos, se utilizó un instrumento con detalle sociodemográfico y ocupacional de los participantes y se entregó una mascarilla N95 a los profesionales para ser utilizada durante la cirugía, con el fin de verificar el tiempo de uso de la N95 y las razones por las que los trabajadores la quitaron durante el acto anestésico-quirúrgico. **Resultados**: el mayor número de trabajadores (27,7%) la utilizó hasta 3 horas durante el acto anestésico-quirúrgico, siendo que ese tiempo fue relacionado con algunas quejas (p=0,037), tales como: incómoda (27,8%), apretada (44,4%) y mareos (5,6%). El hecho de quitarse la mascarilla N95 (p=0,022), por estos profesionales, antes de la finalización de la cirugía se relacionó con estas quejas. **Conclusión**: los trabajadores presentan quejas, como incomodidad, mascarilla apretada y mareos, siendo que estas están relacionadas con el tiempo de uso, lo que necesita ser evaluado por gestores para la utilización de la N95.

Palabras clave: Dispositivos de Protección Respiratoria; Equipo de Protección Individual; Contaminantes Ocupacionales del Aire; Personal de Salud; Enfermería del Trabajo.

REFERENCES

1. Benson SM, Novak DA, Ogg MJ. Proper use of surgical N95 respirators and surgical masks in the OR. AORN Journal. 2013; 97(4):457-67. DOI: https://doi.org/10.1016/j.aorn.2013.01.015

2. Fan JKM, Chan FSY, Chu KM. Surgical Smoke. Asian J Surg. 2009; 32(4):253-57. DOI: https://doi.org/10.1016/S1015-9584(09)60403-6

3. Romano F, Gustén J, De Antonellis S, Joppolo CM. Electrosurgical Smoke: Ultrafine Particle Measurements and Work Environment Quality in Different Operating Theatres. 0Int J Environ Res Public Health. 2017; 14(2):137. DOI: https://doi.org/10.3390/ijerph14020137

4. Limchantra IV, Fong Y, Melstrom KA. Surgical Smoke Exposure in Operating Room Personnel: A Review. JAMA Surg. 2019; 154(10):960-7. Doi: https://doi.org/10.1001/jamasurg.2019.2515

5. Stanganelli NC, Bieniek AA, Margatho AS, Galdino MJ, Barbosa KH, Ribeiro RP. Inhalation of surgical smoke: cohort of signs and symptoms in residents. Acta Paul Enferm. 2019; 32(4):382-89. DOI: http://dx.doi.org/10.1590/1982-0194201900053

6. Ilce A, Yuzden GE, Giersbergen MYV. 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. DOI: https://doi.org/10.1111/jocn.13455

7. Ogg MJ. Guideline for surgical smoke safety. In: Guidelines for Perioperative Practice. AORN [on-line]. 2017. [citado em 03 de mar 2020]; 477-506. Disponível em: http://fumees-chirurgicales.fr/wp-content/uploads/2017/01/Read-article-5.pdf

8. Elmashae Y, Koehler RH, Yermakov M, Reponem T, Grinshpun SA. Surgical smoke simulation study: Physical characterization and respiratory protection. Aerosol Sci Technol. 2018; 52(1):3845. DOI: https://doi.org/10.1080/02786826.2017.1373180

9. Gao S, Koehler RH, Yermakov M, Grinshpun SA. Performance of facepiece respirators and surgical masks against surgical smoke: simulated workplace protection factor study. Ann OccupHyg. 2016; 60(5): 608-18. DOI: https://doi.org/10.1093/annhyg/mew006

10. YildizCÇ, KabanHU ,Tanriverdi FS.COVID-19 pandemic and personal protective equipment: Evaluation of equipment comfort and user attitude. Arch Environ Occup Health. 2020; 16:1-8. DOI: https://doi.org/10.1080/19338244

11. 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. 2017; 25:e2853. DOI: https://dx.doi.org/10.1590/1518-8345.1561.2853

12. Ha HI, Choi MC, Jung SG, Joo WC, Lee C, Song SH, et al. Chemicals in surgical smoke and the efficiency of built-in-filter ports. JSLS.2019; 23(4): e2019.00037. https://doi.org/10.4293/JSLS.2019.00037

13. International Agency For Research On Cancer. European Code Against Cancer: 12 ways to reduce your cancer risk. [on-line]. 2021. [acesso em 14 de mar de 2021]. Disponível em: https://cancer-code-europe.iarc.fr/index.php/en/ecac-12-ways/pollutants-recommendation/165-any-safe-dose-of-exposure-to-cancer-causing-chemical-substances

14. Karjalainen M, Kontunen A, Saari S, Rönkkö T, Lekkala J, Roine A, Oksala N. The characterization of surgical smoke from various tissues and its implications for occupational safety. PLoS One.2018; 13(4):e0195274. DOI: https://doi.org/10.1371/journal.pone.0195274

15. Lourenço MP, Pedro DRC, Costa RG, Pissinati PSC, Rossaneis MA, Haddad MCFL. Adherence to standard precautions among health care workers exposed to accidents with biological material. CiencCuidSaude. 2019; 18(3): e45889. DOI:

https://doi.org/10.4025/cienccuidsaude.v18i3.45889

16. Or PP, Chung JW, Wong TK. A study of environmental factors affecting nurses comfort and protection in wearing N95 respirators during bedside procedures .J ClinNurs. 2018; 27(7-8): e1477-e1484. DOI: https://doi.org/10.1111/jocn.14268

17. Rebmann T, Carrico R, Wang J. Physiologic and other effects and compliance with long-term respirator use among medical intensive care unit nurses. Am J Infect Control. 2013; 41(12): 1218-23. DOI: https://doi.org/10.1016/j.ajic.2013.02.017

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