



## External compression headache during Covid-19 pandemic: a neglected entity

Erlene Roberta Ribeiro dos Santos<sup>1</sup> , Amos Lal<sup>2</sup> , Felipe Maia Tardieux<sup>1</sup> ,  
Elayne Cristina de Oliveira Ribeiro<sup>3</sup> , Henry Martins Soares Fortes<sup>4</sup> , Marcelo Moraes Valença<sup>3</sup> 

<sup>1</sup>Federal University of Pernambuco, Vitória de Santo Antão, Pernambuco, Brazil

<sup>2</sup>Mayo Clinic, Rochester, Minnesota, United States of America

<sup>3</sup>Federal University of Pernambuco, Recife, Pernambuco, Brazil

<sup>4</sup>University of Pernambuco, Recife, Pernambuco, Brazil



Henry Martins Soares Fortes  
henrymsfortes@gmail.com

### Edited by:

Mario Fernando Prieto Peres

### Keywords:

Headache  
Covid-19  
N95 Mask  
Face shield  
Protective Goggles  
Personal Protective Equipment

### Abstract

**Introduction:** Personal Protective Equipment (PPE) is part of the work routine of health professionals, especially during pandemics. During the Covid-19 pandemic, the use of PPE became constant for long working hours, resulting in adverse effects on the health of professionals, especially headache.

**Objective:** In this review, we explore the scientific literature on headache associated with prolonged use of PPE during the coronavirus pandemic.

**Method:** This is a narrative literature review conducted through the PubMed and Web of Science databases according to the following MeSH descriptors: "Face shield", "Headache" and "Covid-19". Articles that analyzed the presence of headache and other adverse events in health professionals in prolonged use of PPE were included.

**Results:** The included studies point to headache as the most prevalent adverse event, which may be a new headache or the worsening of a previous headache. Other effects were also found, such as pressure marks on the skin, hyperemia in contact areas; suffocation; reduced concentration and excessive sweating.

**Conclusion:** The use of PPE for long periods can cause headaches due to external pressure, in addition to other unwanted events. These effects reveal the importance of studies to make PPE more efficient, ensuring protection for the individual without causing discomfort.

Submitted: June 25, 2023  
Accepted: June 29, 2023  
Published online: June 30, 2023



## Introduction

During the Covid-19 pandemic, Personal Protective Equipment (PPE) played a substantial role in the contagion and spread of the coronavirus.<sup>1</sup> During this period, the use of N95 masks, face shields, goggles, aprons, and gloves set became mandatory, constant, and for long consecutive hours of work.

Among the equipment used, the N95 mask is the most widespread and effective in protecting against contaminating droplets.<sup>2</sup> Together, the face shield offers a promissory safety additive, preventing physical contact with the eyes, mouth, and regions from the nose.<sup>3</sup> However, with prolonged use, PPE has been associated with a broad spectrum of adverse effects, from skin depression to headaches.<sup>4</sup> The mask and goggles are the equipment most often associated with external pressure headaches due to pressure points on the scalp.<sup>5</sup>

Therefore, this review aims to explore headaches as an adverse effect of prolonged use of PPE, both in the appearance of new headaches and the worsening of pre-existing headaches.

## Methods

This is a narrative literature review conducted in the PubMed and Web of Science databases during January 2021, using the descriptors "Headache", "Mask N95", "Face shield", "Protective Goggles", and "Personal Protective Equipment" in combination with the Boolean operator AND.

We included original articles published between January 1, 2019, and December 31, 2020, in English, Portuguese, or Spanish, which addressed headaches as an adverse event related to PPE use in the care of patients infected with the coronavirus. Literature reviews, letters to the editor, short communications, conferences, and editorial abstracts were excluded.

The selection of studies was performed by two independent researchers (E.R.R.S. and E.C.O.R.). Divergences were adjusted in a consensual manner. To ensure the validity of these articles, selected studies were analyzed in detail for demographic and clinical characteristics.

## Results

Of the 38 studies found, after the review procedure, 13 duplicates were identified and blindly removed. After reading the titles and abstracts, 15 were also excluded for not meeting the eligibility criteria. Finally, 10 articles were included in the final evaluation and analysis of results (Figure 1). Most studies had a cross-sectional design (70%) and were conducted in Asian countries (60%) (Table 1). All studies identified headaches as one of the events most reported by health professionals in prolonged use of PPE (Table 2). Among the equipment studied, the N95 mask was the most prevalent (100%), followed by goggles (60%) and face shields (30%). A combination of PPE was present in only 30% of the studies (Table 2).

Headache was associated with wearing protective eyewear and face shields for more than four hours ( $p < 0.05$ ).<sup>5</sup> These findings are corroborated by Tabah et al., who observed the presence of headaches according to the time of use of PPE. In shifts shorter than 3h, 18% of individuals reported headache, in shifts longer than 3h, this prevalence progressively increased from 31% to 35%, reaching its maximum in shifts longer than 9h. In univariate logistic regression, this result was presented with an Odds Ratio of 1.13 for each hour of use of PPE ( $p < 0.001$ ).<sup>6</sup>

Changes in cerebral hemodynamics were also identified by one study. Bharatendu et al. compared the results of transcranial middle cerebral artery Doppler in subjects before and during the use of the N95 mask. A significant increase in mean flow velocity ( $p < 0.001$ ) and a significant reduction in pulse index ( $p < 0.001$ ) were observed. End-tidal carbon dioxide (ET-CO<sub>2</sub>) pressure also showed a significant increase during PPE use ( $p < 0.001$ ).<sup>7</sup>

The results of the studies associated the use of PPE both with the appearance of new headaches and with the worsening of existing headaches. New headaches were observed in 28-80% of the individuals analyzed, while previous headaches were identified in 21-25% of these individuals.<sup>7,8</sup> Zaheer et al. found a mostly bilateral (69%), pressure (45.5%) and moderate intensity (69%) pattern in new headaches.<sup>8</sup> Furthermore, individuals previously suffering from headaches have been identified with increased susceptibility to headache induction by EPI.<sup>8,9</sup> Martín-Rodríguez et al.<sup>10</sup> analyzed possible biomarkers in the prediction of head-



aches associated with the use of PPE.<sup>10</sup> Among the analyzed parameters, creatinine was found to be significantly elevated in individuals who developed headaches after 4 hours of use of PPE compared to individuals who did not ( $p = 0.019$ ).<sup>10</sup>

In addition to headaches, the included studies also pointed to psychosocial and work-related effects. Agarwal et al. observed the presence of excessive sweating (100%), fogging of glasses, (88%) suffocation (83%), shortness of breath (61%), fatigue (75%), and pressure marks on the skin (19%) in individuals after prolonged use of PPE.<sup>11</sup> Other symptoms such as reduced concentration and professional performance have also been reported.<sup>6, 12, 13</sup>

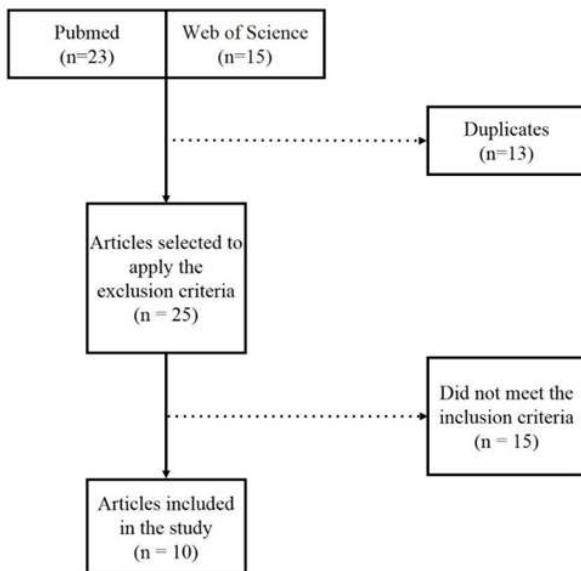


Figure 1. Narrative review flowchart.

Table 1. Studies included in the review

Study	Design	Country	Sample
Atay et al. 2020 <sup>5</sup>	Cross-sectional study	Turkey	n = 307
Agarwal et al. 2020 <sup>11</sup>	Cohort	India	n = 253
Tabah et al. 2020 <sup>6</sup>	Cross-sectional study	90 countries in Europe, Asia and North America	n = 2.711
Hajiji et al. 2020 <sup>12</sup>	Cross-sectional study	Morocco	n=155
Choudhury et al. 2020 <sup>9</sup>	Prospective cohort	India	n = 75
Bharatendu et al. 2020 <sup>7</sup>	Cross-sectional study	Singapore	n = 154
Ong et al. 2020 <sup>4</sup>	Cross-sectional study	Singapore	n = 158
Zaheer et al. 2020 <sup>8</sup>	Cross-sectional study	Pakistan	n = 241
Martín-Rodríguez et al. 2021 <sup>10</sup>	Prospective cohort	Spain	n = 95
Farronato et al. 2020 <sup>13</sup>	Cross-sectional study	Italy	n = 256

Table 1. Studies included in the review

Study	PPE	Adverse events
Atay et al. 2020 <sup>5</sup>	N95 Mask; Face shield and Protective goggles	Headache; Glasses fogging and Hyperemia in contact areas
Agarwal et al. 2020 <sup>11</sup>	N95 Mask; Face shield; Protective goggles and Apron	Headache; Glasses fogging; Skin depression; Fatigue and Suffocation
Tabah et al. 2020 <sup>6</sup>	N95 Mask and Protective goggles	Headache; Glasses fogging; Reduced concentration and Decreased professional performance
Hajiji et al. 2020 <sup>12</sup>	N95 Mask and Protective goggles	Headache (worsening); Glasses fogging; Reduced concentration and Discomfort
Choudhury et al. 2020 <sup>9</sup>	N95 Mask	Headache; Glasses fogging; Fatigue and Suffocation
Bharatendu et al. 2020 <sup>7</sup>	N95 Mask	Headache; Changes in cerebral hemodynamics
Ong et al. 2020 <sup>4</sup>	N95 Mask and Protective goggles	Headache (worsening)
Zaheer et al. 2020 <sup>8</sup>	N95 Mask; KN95 Mask; Face shield and Protective goggles	Headache (worsening)
Martín-Rodríguez et al. 2021 <sup>10</sup>	N95 Mask and Surgical Mask	Headache
Farronato et al. 2020 <sup>13</sup>	N95 Mask and FFP2 Mask	Headache; Suffocation; Reduced concentration and Decreased professional performance

## Discussion

In the present review, headache proved to be a prevalent adverse event during prolonged use of PPE, with the most likely etiology being external compression of superficial nerves in the scalp and face. The most reported sites of pain were the frontal and temporal (bilateral) regions, coinciding with the contact areas of PPE anchorages.<sup>4, 8, 12</sup>

The N95 mask and face shield exert pressure primarily on the occipitofrontal and temporalis muscles and their innervations. Figure 2 demonstrates the relationship between the EPI pressure points and the territory of the cutaneous nerves of the head, branches of the trigeminal nerve, and cervical spinal nerve.

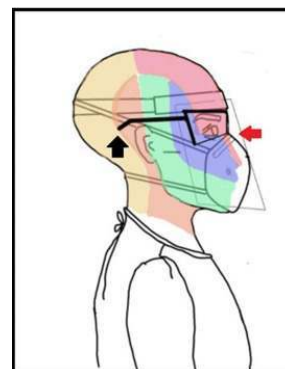


Figure 2. Relationship between PPE straps and cutaneous nerves of the head, trigeminal nerve branches, and cervical spinal nerve branches. The marked regions correspond to the nervous territories: ophthalmic branch of



the trigeminal (pink); maxillary branch of the trigeminal (blue); mandibular branch of the trigeminal (green); major (yellow) and minor (orange) occipital branches of cervical spinal nerves. The black arrow shows the overlapping of elastics and rods in the regions innervated by cervical spinal nerve branches. The red arrow points to the superior nose area overloaded by the adjustment of the metallic clip of the N95 mask and the bridge of the glasses. Image: created by the authors.

This pain mechanism configures the classification of “External compression headache” in the International Classification of Headache Disorders (ICHD-3), described as a “Headache resulting from continued compression of pericranial soft tissues; for example, by a tight band around the head, hat, helmet, or goggles used for swimming or diving, without scalp damage”.<sup>14</sup> Table 3 summarizes the diagnostic criteria for this type of headache.

**Table 3.** Diagnostic criteria for external compression headache according to ICHD-3 criteria<sup>14</sup>

Criteria	Description
A	At least two episodes of headache fulfilling criteria B-D
B	Provoked by and occurring within an hour during continued external compression of the forehead or scalp
C	Maximum at the site of external compression
D	Disappearing within an hour after external compression is relieved
E	Not better explained by another ICHD-3 diagnosis.

Among the uncommon primary headaches, external compression headache is still poorly studied. In patients with a history of pre-existing headaches, the compression generated by the adornment may increase the chances of triggering an attack with greater intensity, if the causal factor has been present for a long time, as in the prolonged use of PPE.<sup>4, 6, 15-17</sup>

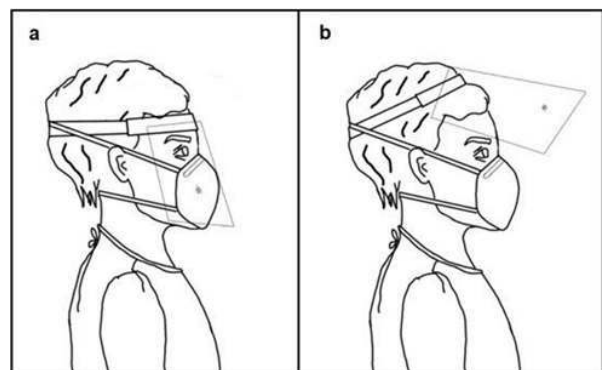
The results of our review corroborate previous data on headaches with prolonged use of N95 masks. In a study carried out during the Severe Acute Respiratory Syndrome epidemic in 2003, 37.3% of individuals reported headaches after prolonged use of N95 masks, of which 32.9% reported a frequency of more than six episodes per month.<sup>16</sup>

The use of a mask for long periods also causes superficial skin lesions, due to the pressure exerted on the soft tissues of the face and head, leaving marks on the upper part of the nose, zygomatic region, and ear.<sup>1, 5</sup> Studies have shown that the mask The N95 face mask effectively protects against respiratory droplets, but the material that composes it, such as the metal clip, can cause abrasions on the nasal bridge, followed by a prolonged painful sensation of the facial tissues.<sup>18,19</sup> Other mask components, such as the thick stitching on the cheek area and two elastic bands that wrap around the head and the neck can intensify the discomfort.

The design and materials used in the manufacture of PPE have already been criticized in surgical practice, a previous study identified impaired performance in the operating room (54%), difficulty in visualizing (63%), communication problems (54%), increased fatigue during surgery (82%), suggesting more attention in the manufacture of this equipment.<sup>20</sup> In another study, nurses and respiratory therapists also suggested improvements in mask design, such as size, shape, straps, nose clip, and odor, the latter being the most mentioned.<sup>21</sup>

The mask can also impair breathing due to CO2 levels increase and hemodynamic changes.<sup>7, 9, 13, 17</sup> This increase in carbon dioxide can also cause changes in heart rate and blood pressure, leading to the symptom of fatigue observed in our review.<sup>9</sup>

In 12 hours of an average work period, the PPE change can occur on average twice. However, depending on the conditions, there may be an uninterrupted use.<sup>11</sup> In these cases, professionals often change the position of the equipment in an attempt to alleviate the pain points, generating more comfort for the individual at the expense of a greater risk of contamination (Figure 3).



**Figure 3.** Combined use of N95 mask and face shield; (3a) Correct use of face shield; (3b) Incorrect use of face shield. Note that in order to relieve pressure in the frontal region, the face shield was incorrectly positioned. Image: created by the authors.

All healthcare professionals require the use of PPE to perform their duties safely. The undesired effects of the combined use of the equipment are consensus in the literature, especially in the population with pre-existing headache risk factors. Headaches resulting from the combined use of a mask, goggles, and face shield may arise due to the pressure of the strap on the neck or occipital area on superficial nerves, which can aggravate an underlying cervical tension and potentiate the headache associated with PPE.<sup>16</sup>



## Conclusion

Adverse events associated with the prolonged use of PPE such as an N95 mask, face shield, and goggles range from physical and cosmetic (observed in the skin tissue in contact with the mask material) to the most worrying cases of headache associated with the use prolonged use of equipment or exacerbation of pre-existing headache. These can affect the performance of the health professional, as well as their occupational health. Given the current Covid-19 scenario and the results of this review, we recommended investment in improving protective equipment. Other measures that may minimize these events are: avoiding the prolonged use of PPE at work, avoiding long working hours, and improving equipment design.

Erlene Roberta Ribeiro dos Santos  
<https://orcid.org/0000-0003-3334-3408>  
 Amos Lal  
<https://orcid.org/0000-0002-0021-2033>  
 Felipe Maia Tardieux  
<https://orcid.org/0000-0001-8275-1243>  
 Elayne Cristina de Oliveira Ribeiro  
<https://orcid.org/0000-0002-5243-3356>  
 Henry Martins Soares Fortes  
<https://orcid.org/0000-0003-3963-9058>  
 Marcelo Moraes Valença  
<https://orcid.org/0000-0003-0678-3782>

### Funding

The authors have no competing interests to declare.

### Conflict of interests

The authors report no conflict of interest

### Contribution authors

ERRS, Conceptualization, Investigation, Writing - Original Draft, Writing - Review & Editing; AL, Writing - Original Draft, Writing - Review & Editing; FMT, Writing - Original Draft, Writing - Review & Editing; ECOR, Investigation, Writing - Original Draft, Writing - Review & Editing; HMSF, Writing - Original Draft, Writing - Review & Editing; MMV, Writing - Original Draft, Writing - Review & Editing.

### Declaration

This manuscript is an updated version of the chapter "Cefaleia por pressão externa: uma entidade frequente e menos reconhecida" published in Portuguese in the printed book "Cefaleia vol. 1".

## References

- Gordon C and Thompson A. **Use of personal protective equipment during the COVID-19 pandemic** *British Journal of Nursing* 2020;29(13):748-752 Doi: 10.12968/bjon.2020.29.13.748
- Seto WH, Tsang D, Yung RWH, Ching TY, Ng TK, Ho M, . . . Peiris JSM. **Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS)** *The Lancet* 2003;361(9368):1519-1520 Doi: 10.1016/s0140-6736(03)13168-6
- Wendling J-M, Fabacher T, Pébaÿ P-P, Cosperec I and Rochoy M. **Experimental Efficacy of the Face Shield and the Mask against Emitted and Potentially Received Particles** *International Journal of Environmental Research and Public Health* 2021;18(4):Doi: 10.3390/ijerph18041942
- Ong JJY, Bharatendu C, Goh Y, Tang JZY, Sooi KWX, Tan YL, . . . Sharma VK. **Headaches Associated With Personal Protective Equipment – A Cross-Sectional Study Among Frontline Healthcare Workers During COVID-19** *Headache: The Journal of Head and Face Pain* 2020;60(5):864-877 Doi: 10.1111/head.13811
- Atay S and Cura SU. **Problems Encountered by Nurses Due to the Use of Personal Protective Equipment During the Coronavirus Pandemic: Results of a Survey** *Wound Manag Prev* 2020;66(10):12-16
- Tabah A, Ramanan M, Laupland KB, Buetti N, Cortegiani A, Mellinshoff J, . . . De Waele JJ. **Personal protective equipment and intensive care unit healthcare worker safety in the COVID-19 era (PPE-SAFE): An international survey** *Journal of Critical Care* 2020;59(70-75) Doi: 10.1016/j.jcrc.2020.06.005
- Bharatendu C, Ong JJY, Goh Y, Tan BYQ, Chan ACY, Tang JZY, . . . Sharma VK. **Powered Air Purifying Respirator (PAPR) restores the N95 face mask induced cerebral hemodynamic alterations among Healthcare Workers during COVID-19 Outbreak** *Journal of the Neurological Sciences* 2020;417(Doi: 10.1016/j.jns.2020.117078
- Zaheer R, Khan M, Tanveer A, Farooq A and Khurshid Z. **Association of Personal Protective Equipment with De Novo Headaches in Frontline Healthcare Workers during COVID-19 Pandemic: A Cross-Sectional Study** *European Journal of Dentistry* 2020;14(S 01):S79-S85 Doi: 10.1055/s-0040-1721904



9. Choudhury A, Singh M, Khurana DK, Mustafi SM and Sharma S. **Physiological Effects of N95 FFP and PPE in Healthcare Workers in COVID Intensive Care Unit: A Prospective Cohort Study** *Indian Journal of Critical Care Medicine* 2021;24(12):1169-1173 Doi: 10.5005/jp-journals-10071-23671
10. Martín-Rodríguez F, López-Izquierdo R, Portillo Rubiales RM, Fadrique Millán LN, Carbajosa Rodríguez V, Sanz-García A, . . . Martín-Conty JL. **Blood Biomarkers for Assessing Headaches in Healthcare Workers after Wearing Biological Personal Protective Equipment in a COVID-19 Field Hospital** *Journal of Personalized Medicine* 2021;11(1):Doi: 10.3390/jpm11010027
11. Agarwal A, Agarwal S and Motiani P. **Difficulties Encountered While Using PPE Kits and How to Overcome Them: An Indian Perspective** *Cureus* 2020;Doi: 10.7759/cureus.11652
12. Hajjij A, Aasfara J, Khalis M, Ouhabi H, Benariba F and El Kettani C. **Personal Protective Equipment and Headaches: Cross-Sectional Study Among Moroccan Healthcare Workers During COVID-19 Pandemic** *Cureus* 2020;Doi: 10.7759/cureus.12047
13. Farronato M, Boccalari E, Del Rosso E, Lanteri V, Mulder R and Maspero C. **A Scoping Review of Respirator Literature and a Survey among Dental Professionals** *International Journal of Environmental Research and Public Health* 2020;17(16):Doi: 10.3390/ijerph17165968
14. **The International Classification of Headache Disorders, 3rd edition (beta version)** *Cephalalgia* 2013;33(9):629-808 Doi: 10.1177/0333102413485658
15. Krymchantowski AV. **Headaches Due to External Compression** *Current Pain and Headache Reports* 2010;14(4):321-324 Doi: 10.1007/s11916-010-0122-x
16. Lim ECH, Seet RCS, Lee KH, Wilder-Smith EPV, Chuah BYS and Ong BKC. **Headaches and the N95 face-mask amongst healthcare providers** *Acta Neurologica Scandinavica* 2006;113(3):199-202 Doi: 10.1111/j.1600-0404.2005.00560.x
17. Rhee MSM, Lindquist CD, Silvestrini MT, Chan AC, Ong JJY and Sharma VK. **Carbon dioxide increases with face masks but remains below short-term NIOSH limits** *BMC Infectious Diseases* 2021;21(1):Doi: 10.1186/s12879-021-06056-0
18. Hu K, Fan J, Li X, Gou X, Li X and Zhou X. **The adverse skin reactions of health care workers using personal protective equipment for COVID-19** *Medicine* 2020;99(24):Doi: 10.1097/md.00000000000020603
19. Alonso-Blanco C, Fernández-de-las-Peñas C, Fernández-Mayoralas DM, de-la-Llave-Rincón AI, Pareja JA and Svensson P. **Prevalence and Anatomical Localization of Muscle Referred Pain from Active Trigger Points in Head and Neck Musculature in Adults and Children with Chronic Tension-Type Headache** *Pain Medicine* 2011;12(10):1453-1463 Doi: 10.1111/j.1526-4637.2011.01204.x
20. Yáñez Benítez C, Güemes A, Aranda J, Ribeiro M, Ottolino P, Di Saverio S, . . . Yáñez C. **Impact of Personal Protective Equipment on Surgical Performance During the COVID-19 Pandemic** *World Journal of Surgery* 2020;44(9):2842-2847 Doi: 10.1007/s00268-020-05648-2
21. Locatelli SM, LaVela SL and Gosch M. **Health Care Workers' Reported Discomfort While Wearing Filtering Face-Piece Respirators** *Workplace Health & Safety* 2014;62(9):362-368 Doi: 10.3928/21650799-20140804-03