



Headache related to personal protective equipment in healthcare workers during COVID-19 pandemic in Mexico: baseline and 6-month follow-up

Rogelio Dominguez-Moreno¹ · Venny A. Venegas-Gómez² · Luis Asdrual Zepeda-Gutiérrez² · Juan José De La Rosa-Cuevas¹ · Jorge Humberto Hernández-Félix¹ · Edgar Omar Martos-Armendariz¹ · Erwin Chiquete¹ · Felipe Vega-Boada¹ · Fernando Flores-Silva¹ · Carlos Cantú-Brito¹

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Abstract

Background and aim Headaches related to the use of personal protective equipment (PPE) could affect performance at work in healthcare personnel. Our aim was to describe the prevalence and risk factors for headaches related to PPE, in the personnel of a specialized coronavirus disease 2019 (COVID-19) tertiary hospital.

Methods In this cross-sectional survey study, we invited healthcare workers from COVID-19 referral center in Mexico (May 22–June 19, 2020) to answer a standardized structure questionnaire on characteristics of new-onset PPE-related headache or exacerbation of primary headache disorder. Participants were invited regardless of whether they had a current headache to avoid selection bias. This is the primary analysis of these data.

Results Two hundred and sixty-eight subjects were analyzed, 181/268 (67.5%) women, 177/268 (66%) nurses, mean age 28 years. The prevalence of PPE-related headache was 210/268 (78.4%). Independent risk factors were occupation other than physician (OR 1.59, 95% CI 1.20–2.10), age > 30 years (OR 2.54, 95% CI 1.25–5.14), and female sex (OR 3.58, 95% CI 1.86–6.87). In the 6-month follow-up, 13.1% of subjects evolve to chronic headache, with stress as predictive risk factor.

Conclusion The frequency of PPE-associated headache is high, and a subgroup could evolve to chronic headache. More studies are necessary to improve the knowledge about this condition.

Keywords COVID-19 · Headache · Migraine · Personal protection equipment

Introduction

In December 2019, a number of cases of pneumonia of unknown etiology were reported in Wuhan City, Hubei Province of China (World Health Organization 2020a). The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was identified as being responsible for the disease latter designated as coronavirus disease COVID-19 (Zhu et al. 2019). On February 28, the first case of COVID-19

was confirmed in Mexico (Dirección General de Epidemiología 2019; Chiquete et al. 2020). On March 11, the World Health Organization declared a pandemic of this new disease (World Health Organization 2020b). As of December 2020, in Mexico, there have been more than 1.2 million cases of SARS-CoV-2 infection and more than 100,000 deaths, for a case fatality rate of 9.3% (Inteligencia and Epidemiológica y Sanitaria 2020). As part of the strategies to decrease the risk of transmission in healthcare workers, continuously changing recommendations have been established for the use of personal protective equipment (PPE) during the COVID-19 pandemic. This PPE includes, among other measures, eye protection and the use of N95 masks that are used throughout the workday.

Symptoms related to the use of PPE equipment can affect performance at work in healthcare personnel (Rebmann et al. 2013; Tabah et al. 2020). Rebmann et al., evaluated the physiological effects of PPE use and found that 22% of nurses

✉ Rogelio Dominguez-Moreno
rogelio_dm@hotmail.com

¹ Department of Neurology, National Institute of Medical Sciences and Nutrition Salvador Zubirán, Ciudad de Mexico, México

² Department of Internal Medicine, National Institute of Medical Sciences and Nutrition Salvador Zubirán, Ciudad de Mexico, México

in the intensive care unit (ICU) stopped using PPE due to disabling symptoms, headache was highlighted as one of the main reasons (Tabah et al. 2020). Headache caused by external physical compression is well described in the medical literature, affecting workers who require PPE as in the case of the police and military personnel, as well as in swimmers due to the prolonged use of goggles (Rahmani et al. 2017; Krymchantowski et al. 2004; May 2020; International Classification of Orofacial Pain 2020; O'Brien 2004).

The international headache society establishes as external-compression headache that headache resulting from sustained compression or traction on pericranial soft tissues (International Classification of Orofacial Pain 2020; Headache Classification Committee of the International Headache Society (IHS) 2018). This must occur at least two different times within the first hour of sustained compression and resolve within the first hour after removal of external compression. There are only a few studies addressing specifically the frequency of headache related to PPE in healthcare workers (Tabah et al. 2020; Lim et al. 2006; Ong et al. 2020). Lim et al. 16 during the 2006 SARS pandemic reported a prevalence of 37.3%. Recently, during the COVID-19 pandemic, Ong et al. reported a very high prevalence of 81% (Ong et al. 2020).

In Mexico, since the beginning of the contingency (March 2020), our hospital was converted as a national reference center for patients with COVID-19 (Chiquete et al. 2020; Ortiz-Brizuela et al. 2020; Olivares-Gazca et al. 2020; Kammar-García et al. 2020). This conditioned the adoption of the international recommendations on the use of PPE to reduce the risk of infection among healthcare workers. Our objective was to determine the prevalence of and independent risk factors for PPE-related headache. According to previous data reported, we hypothesized that the frequency of headache related to PPE could be > 50% and associated with primary headache, and stress as predictors.

Methods

Cross-sectional survey study was conducted at the Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán (INCMNSZ) in the emergency department and the general wards. The design of this survey and the organization of the present report were prepared in accordance to the STROBE guidelines (Elm et al. 2007). A total of 268 individuals agreed to participate, all of them are part of the health personnel of the Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán, in Mexico City. All the selected participants met the inclusion criteria, which were: being over 18 years of age, Healthcare workers who have worn PPE in the last month, with/without a history of primary headache. All signed a written informed consent.

Exclusion criteria were: secondary headache (known or determined during the evaluation), steroid use in the past 2 weeks and participants who have decided to leave the study at any time. Due to the descriptive nature of the study, convenient sampling was used to obtain the sample size. To select subjects, all physicians, nurses and other healthcare workers who are caring for patients with COVID-19 were invited to participate (with an emphasis on including the largest number of participants and not only those with headaches, to avoid selection bias) who are working in the emergency room, intensive care, semi-critical, observation unit and hospitalization where they use the complete personal protective equipment (N95 mask and/or goggles). The researchers went to the different areas to invite the staff to answer the survey, the consent was signed and the survey was sent to them by mail or with a QR code to be answered by the participant afterwards. The rate of headache events was taken based on the self-report of the previous months, however, after the survey was done, the use of a headache calendar for follow-up was advised, we assume that as the majority of participants were physicians and nurses, this self-report of headache frequency, intensity, and other characteristics are reliable.

The study was approved by the Ethics and Research Committee of the INCMNSZ on May 15, 2020 (Ref. 3395) in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. A baseline survey was applied from May to June 2020 and a 6-month follow-up survey was applied from November to December 2020. This online open survey represents a modified version of the HAPPE survey developed for related to with PPE (Ong et al. 2020), but it was decided to add more characteristics related to the presence of exacerbated primary headache, as well as on the pattern of analgesic use and an additional section on facial pain was included, approved by the local Institutional Review Board with informed consent. The sections contemplated in this survey were: identification of the participant by sex, age, nationality, email, occupation and department of the Institute in which he works (it was decided to omit the personal name), digital consent to carry out the survey, demographic characteristics, history including clinically relevant comorbidities (diabetes mellitus, systemic arterial hypertension, hypothyroidism, hyperthyroidism, cerebrovascular disease, ischemic heart disease, anxiety, depression, smoking, and asthma), the presence of pre-existing primary headache, characteristics and changes in the pre-existing primary headache (type of primary headache, monthly frequency and changes in frequency, uncontrolled headache, duration, intensity, exacerbating agents and type of pain), patterns of use of personal protective equipment (number of days per month and hours per day in wearing N95 mask or equivalent; type of eye protection, number of days per month and hours per day wearing eye protection;

number of days per month and hours per day wearing the N95 respirator and eye protection together; presence or absence of new headache related to PPE), characteristics of the new-onset headache (associated with the use of an N95 mask, eye protection or both; time interval between PPE placement and the onset of headache; time interval between removal of PPE and resolution of symptoms; type of pain, most common location, pressure zones identified, severity of pain, associated symptoms, quality of life impairment and use of analgesics to relieve pain), presence and characteristics of facial pain. The visual analog scale (VAS, 0–10 severity points, 0 meaning the absence of pain and 10 the worst severity) was used to stratify the magnitude of the subjective experience of the headaches. In the survey process, there was no loss of data because the questionnaire was previously explained, and this is a population familiar with filling out surveys. To avoid double response, a member of the research group reviewed and discarded duplicate data. This was a primary analysis of the data.

Statistical analyses

No statistical power calculation was conducted prior to the study, and sample size was selected based on the previous reported in the HAPPE study, the proposal was to collect at least 154 participants as in the commented study and we obtained a higher sample size.

The dependent variables were external-compression headache and PPE-related headache. The independent variables were age, sex, occupation (MD, nurse, other), work area (emergency room, ICU, hospitalization floor), comorbidities, history of primary headache, PPE wear pattern, PPE wearing time, characteristics of de novo headache, characteristics of modified primary headache, use of painkillers and characteristics of facial pain. Relative frequencies are expressed as percentages. For the relevant relative frequencies, 95% confidence intervals (CI) were calculated with the adjusted Wald method. Parametric continuous variables are expressed as geometric means with standard deviations (SD). Non-parametric continuous variables are expressed as medians with minimum and maximum or interquartile range. Pearson Chi-square or Fisher exact tests will be used to assess proportions in nominal variables for bivariate analyses. The distribution of variables was analyzed using the Kolmogorov–Smirnov test. The difference between two groups was tested with Student *t* test for independent samples, provided the distribution of the variables was normal, or Mann–Whitney *U* test if this premise was not met. To find independent predictors of PPE-related headache and moderate-to-severe PPE-related headache (VAS scoring > 6), multivariable analyses were constructed by forward stepwise logistic regression. A first step selection process was performed with a *p* set at < 0.1 in bivariate analyses to select putative independent variable to

integrate the multivariable models, to avoid the multicollinearity we performed a correlation matrix analysis where the resulting *R* values were always less than 0.1 among the different independent variables, which helps to rule out multicollinearity. Adjusted odds ratios (OR) with the respective 95% CIs were calculated. The fitness of the models was evaluated by the Hosmer–Lemeshow goodness-of-fit test, which will be considered as reliable if *p* > 0.2. All *p* values are two-sided and considered significant when *p* < 0.05. SPSS version 24.0 for Mac OS was used in all calculations.

Results

Two hundred and sixty-eight healthcare workers agreed to fulfill the questionnaire (overall response rate: 61.5%) (Table 1). Most of the responders were female 181 (67.5%), and the median age was 28 (25–34) years. The

Table 1 Characteristics of healthcare workers attending participants with COVID-19.

Characteristics	Frequency <i>N</i> = 268
Headache associated with PPE, <i>n</i> (%)	210 (78.4)
Female gender (female), <i>n</i> (%)	181 (67.5)
Age, median (CI), years	28 (25–34)
Occupation, <i>n</i> (%)	
Nurse	177 (66)
Physician	67 (25)
Laboratory personnel	15 (5.6)
Cleaning staff	4 (1.5)
Other	5 (1.9)
Department, <i>n</i> (%)	
Intensive care unit	137 (51.1)
Floor	72 (26.9)
Emergency room	55 (20.5)
Other	4 (1.5)
Comorbidities, <i>n</i> (%)	57 (21.3)
Smoking	18 (6.7)
Anxiety	12 (4.5)
Depression	2 (0.7)
Asthma	5 (1.9)
Hyperthyroidism	5 (1.9)
Hypertension	1 (0.4)
Diabetes mellitus	1 (0.4)
Not specified	13 (4.9)
Primary headache, <i>n</i> (%)	69 (25.7)
Migraine	50 (58)
With aura	21 (27.5)
Without aura	19 (30.5)
Type tensional	29 (42)
COVID-19	22 (8.2)

majority of the participants were nurses in 177 (66.0%) cases, followed by physicians in 67 (25.0%), and laboratory personnel in 15 (5.6%) cases. Most of the responders worked in the ICU (137 participants, 51.1%) and the general wards (72 participants, 26.9%). The presence of comorbidities was reported in 57 (21.3%) cases; pre-existing primary headache was present in 69 responders (25.7%, mainly migraine), and recent history of COVID-19 in 22 (8.2%) participants.

Characteristics of the PPE usage

The 268 healthcare workers reported different PPE utilization patterns according to the area of work (Table 2). The median number of days wearing facial mask were 8 days and 6 h per day in the last month, the main type of eye protection was goggles in 204 (76.1%) participants, with 84.7% reporting significant increase in the frequency of PPE use. In overall, the participants classified as other than physician use the PPE in similar hours per event but more days per month (Table 3).

Table 2 PPE usage patterns among healthcare workers attending COVID-19

Characteristics	Healthcare workers <i>N</i> = 268
Facial mask usage	
Number of days wearing facial mask (N95 or KN95) in the last 30 days; median (IQR)	8 (7–16)
Number of hours per day wearing facial mask; median (IQR)	6 (5–8)
Eye protection usage	
Number of days wearing eye protection in the last 30 days; median (IQR)	20 (10–24)
Number of hours per day wearing eye protection; median (IQR)	6 (5–7)
Type of eye protection, <i>n</i> (%)	
Goggles	204 (76.1)
Face shield	25 (9.3)
Eyeglasses	11 (4.1)
Complete adapted visor	28 (10.4)
Combination facial mask and eye protection usage	
Number of days wearing in combination in the last 30 days; median (IQR)	15.5 (9–22)
Number of hours per day wearing in combination; median (IQR)	6 (5–7)
Change in the frequency of PPE usage since the COVID-19 outbreak, <i>n</i> (%)	
Significant increase in frequency	227 (84.7)
Slight increase in frequency	16 (6)
No change in frequency	23 (8.6)
Significant decrease in frequency	1 (0.4)
Slight decrease in frequency	1 (0.4)

Table 3 Time of PPE use among healthcare workers with headache related to PPE by occupation subgroup

Characteristics	Physician <i>N</i> = 35	Other than physician <i>N</i> = 175	<i>p</i> value
Facial mask usage			
Number of days wearing facial mask (N95 or KN95) in the last 30 days; median (IQR)	8 (8–10)	21 (20–22)	0.121
Number of hours per day wearing facial mask; median (IQR)	6 (5–12)	6 (5–7)	0.008
Eye protection usage			
Number of days wearing eye protection in the last 30 days; median (IQR)	8 (8–15)	22 (15–25)	<0.001
Number of hours per day wearing eye protection; median (IQR)	6 (5–8)	6 (5–7)	0.898
Combination facial mask and eye protection usage			
Number of days wearing in combination in the last 30 days; median (IQR)	8 (8–13)	20 (12–24)	<0.001
Number of hours per day wearing in combination; median (IQR)	6 (5–8)	6 (5–7)	0.466

Characteristics of PPE-related headache

A total of 210 healthcare workers (78.40%, 95% CI 73.0–82.9%) were identified with headaches related to PPE, the vast majority claimed to have used mixed PPE ($n = 149$, 71.0%) (Table 4). Regarding the occurrence of this headache according to the occupation, this was mostly reported in the occupation other than physician (83.3 vs 16.7%, $p < 0.001$) and in the female subgroup this occupation represented most of cases (89.9 vs 10.1%, $p < 0.001$). Most headaches were described as pressing ($n = 130$, 61.9%), predominantly frontal ($n = 70$, 33.0%), holocranial ($n = 52$, 24.8%), and with nausea or vomiting ($n = 63$, 30.0%). The most important exacerbating factor recorded was stress, reported by 166 participants (79%). It is important to mention that most participants with new-onset PPE-related headache were not under medication to treat their symptoms ($n = 141$, 67.1%), while 20 participants (9.5%) used analgesics to prevent a PPE-related headache, and 44 participants (21.0%) confirmed that they were already being medically treated for it.

Characteristics of PPE-related headache according to severity

We analyzed several characteristics according to headache severity; the group with a headache intensity ≤ 6 in VAS, and the group with headache intensity > 6 (moderate-to-severe headache). Compared with the group with headache intensity ≤ 6 in VAS, the moderate-to-severe PPE-related headache group was older, with a lower proportion of females, with a higher frequency of pre-existing primary headache, with a greater proportion of headache days > 15 per month, and with a higher proportion reporting low performance at work as a consequence to headache, among other differences (Table 5).

Risk factors linked to PPE-related headache

We analyzed the factors potentially associated with PPE-related headache. The adjusted multivariable analysis revealed that independent risk factors for PPE-related headache were occupation other than physician, age > 30 years, and female sex. In the multivariable analysis constructed to find potential predictors for moderate-to-severe headache (VAS ≥ 6), the independent factors identified were age > 30 years, occupation other than physician, eye protection usage > 2 h per day, and previous diagnosis of migraine (Table 6).

6-month follow-up

57.7% (160/268) of the health care workers completed the follow-up questionnaire at month 6, the rest was not possible

because they were temporary workers. In this timepoint, 59.4% (65/160) fill out the definition for headache related with PPE, and 13.1% (21/160) meet the ICHD-3 for chronic migraine/type tensional headache (15 or more days/month for more than 3 months), 11.3% (18/160) complete the criteria for medication overuse headache. Regarding the headache evolution during this follow-up period, we made four different scenarios, been persistent headache (headache since the baseline through the 6-month follow-up) the most common scenario 71/160 (44%) (Table 7). Finally, in multivariable regression analysis, the only factor associated with chronicity was stress 3.20 (1.06–9.65, $p = 0.038$).

Discussion

In the present study, the frequency of PPE-related headache in hospital personnel dedicated to the management of patients with COVID-19 was high. Moreover, among affected individuals with PPE-related headache, more than half experienced headaches of moderate-to-severe intensity. Regarding the time interval between the placement of the PPE and the onset of the headache, most of the participants reported starting with the headache within the first 60 min of use ($n = 128$, 60.9%), which is consistent with the definition of headache related to external-compression mechanisms. Analyzing the time between removing the PPE and the resolution of symptoms, it is striking that 57.1% ($n = 120$) resolve within the first hour, while the remaining 41.8% ($n = 90$) resolve within 4 h.

Our study revealed a higher frequency than that reported by Lim et al. in the first SARS pandemic in 2003, where they reported headache related with N95 mask in 37.3% of the healthcare workers. They found that the use of N95 mask for ≥ 4 h per day (OR 1.85, 95% CI 0.99–3.43, $p = 0.053$), and previous primary headache (OR 1.97, 95% CI 1.03–3.77, $p = 0.041$) increased the risk of new-onset PPE headache (Lim et al. 2006). Our results are similar to those recently reported by Ong et al. (HAPPE), a study that evaluated the prevalence of new-onset headache related with PPE in healthcare workers during the current COVID-19 pandemic in Singapore (Ong et al. 2020). In the HAPPE study, it was found that 81% of health workers had headaches; in overall, the median frequency reported of these headaches is 48.3% (26.5–81%) (Ong et al. 2020; Atay and Cura 2020; Zaheer et al. 2020; Hajjij et al. 2020; Ramirez-Moreno et al. 2020; Rapisarda et al. 2021; Koseoglu Toksoy et al. 2021; Marfil-Rivera et al. 2021; Jafari et al. 2021). Ong et al. also found that the pre-existing primary headache (OR = 4.20, 95% CI 1.48–15.40) and the use of PPE for ≥ 4 h per day (OR 3.91, 95% CI 1.35–11.31) were the factors associated with PPE-related headache. The independent risk factors associated with headache in our study were age > 30 years, female sex,

Table 4 Characteristics of headache associated with PPE in 210 participants

Characteristic	Frequency <i>N</i> =210
Related to, <i>n</i> (%)	
Goggles	48 (22.9)
Facial mask (N95 or KN95)	13 (6.1)
Both	149 (71)
Time interval between wearing PPE to onset of headache, <i>n</i> (%)	
< 15 min	11 (5.2)
15–30 min	33 (15.7)
30–45 min	40 (19)
45–60 min	44 (21)
1–4 h	79 (37.6)
> 4 h	3 (1.4)
Time interval from removal of PPE to resolution of headache, <i>n</i> (%)	
< 15 min	18 (8.6)
15–30 min	33 (15.7)
30–45 min	33 (15.7)
45–60 min	36 (17.1)
1–4 h	80 (38.1)
> 4 h	10 (3.7)
Quality of headache, <i>n</i> (%)	
Throbbing	30 (14.3)
Stabbing	50 (23.8)
Pressing	130 (61.9)
Localization, <i>n</i> (%)	
Frontal	70 (33.0)
Holocranial	52 (24.8)
Pressure sites	39 (18.6)
Parietotemporal	35 (16.7)
Occipital	13 (6.2)
Central	1 (0.5)
Intensity in VAS, median (IQR)	6 (5–7)
Month headache days, median (IQR)	7 (4.7–15)
Months with headache, median (IQR)	2 (1–2)
Analgesic usage, <i>n</i> (%)	
None	141 (67.1)
Yes, preventive for headache	20 (9.5)
Yes, as treatment for headache	44 (21)
Yes, for other different of headache	5 (2.4)
Analgesic monthly usage, median (IQR)	2 (2–5)
Associated symptom during headache attack, <i>n</i> (%)	
Nausea/vomiting	63 (30)
None	36 (17.1)
Neck pain	36 (17.1)
Light sensitivity	27 (12.9)
Disability	24 (11.4)
Sound sensitivity	15 (7.1)
Exacerbated with exercise	9 (4.3)
Exacerbating factors associated, <i>n</i> (%)	
Stress	166 (79)
Insomnia	28 (13.3)
Anxiety	26 (12.4)

Table 4 (continued)

Characteristic	Frequency N=210
Irregular meal times	39 (18.6)
Insufficient hydration	22 (10.5)
Work affecting, <i>n</i> (%)	
None	117 (55.7)
Mild	81 (38.6)
Severe	12 (5.7)
Facial pain associated with headache, <i>n</i> (%)	151 (71.9)
Quality of facial pain, <i>n</i> (%)	
Pressure	112 (74.2)
Stabbing	32 (21.2)
Electric	5 (3.3)
Other	2 (1.3)
Duration of facial pain, <i>n</i> (%)	
< 15 min	18 (11.9)
15–30 min	28 (18.5)
30–45 min	25 (16.6)
45–60 min	34 (22.5)
1–4 h	43 (28.5)
> 4 h	3 (2)
Outcome of facial pain, <i>n</i> (%)	
Resolution	119 (78.8)
Need of analgesic usage	20 (13.2)
Constant	12 (8)

and occupation other than physician (mainly nurses), but the length of PPE use was not significantly associated. For moderate-to-severe headache, the predictor risk factors were age > 30 years, occupation, a previous diagnosis of migraine, and eye protection use for > 2 h per day. These results are relevant because they suggest a direct relationship between the length of PPE use (particularly eye protection) and the development of headaches in the most severe scenario. This is also supported by the fact that in this pandemic goggles use is reported in a significantly higher frequency than that during the SARS 2003 pandemic. Moreover, severe headaches related with the use of eye protection equipment have a plausible neurobiological explanation due to the pressure over the nerves and muscles relevant in headaches and facial pain (Lance et al. 2000).

The first descriptions of compression headache were found with the use of swimming goggles, curiously described by neurologists who were affected (Jacobson 1983; Pestronk and Pestronk 1983). Part of the mechanisms that may be involved in the pathophysiology of this entity is the direct compression of the nerves that are located in the area where the eye PPE is placed, although hypoxia and hypercapnia have also been proposed as probable triggers (Lance et al. 2000; Jacobson 1983; Pestronk and Pestronk 1983; Bharatendu et al. 2020). Thus, the nerves located

below the PPE pressure sites that may be more frequently involved due to their anatomical location are the terminal branches of the trigeminal nerve (supraorbital, supratrochlear, nasociliary, and nasociliary nerves), and of the cervical nerves (mainly the greater and lesser occipital nerves).

In this report, the most important characteristics of a new-onset headache associated with the use of PPE were the frontal and holocranial locations, with an pressing nature in about 60% cases, which at first sight reminds the classical tension-type headache. However, nausea and vomiting were the most frequent associated symptoms, found in one third of the participants, as well as symptoms such as photophobia and sonophobia that reminds migraine or nerve-compression headaches, as it is reported in the occipital neuralgia. Women reported a greater frequency and severity of headaches, compared with men. Progesterone and estrogens have been proposed to have an effect on neurotransmission systems, directly intervening in the pathophysiology of some primary headaches (Warfvinge et al. 2020; Silberstein and Merriam 1999). This could be an important contributing mechanism that explains why are women more affected than men. Nonetheless, it is important to note that about 67% of our study population was composed by women, that mainly define the other than physician group. It is noteworthy that other occupations such as laboratory technician, cleaning

Table 5 Characteristics of headache according to severity (attacks with intensity > 6)

Variable	Without headache <i>n</i> = 58	Headache intensity < 6 <i>n</i> = 87	Headache intensity > 6 <i>n</i> = 123	<i>P</i> value
Age (years)	27 (25–29)	27 (25–35)	31 (26–37)	0.003
Female gender <i>n</i> (%)	23 (39.7)	72 (82.8%)	86 (69.9%)	<0.001
Nurse <i>n</i> (%)	22 (37.9)	64 (73.6)	91 (74)	<0.001
Comorbidities <i>n</i> (%)	9 (15.5)	15 (17.2)	33 (26.8)	0.119
Previous COVID-19 diagnosis <i>n</i> (%)	5 (8.6)	7 (8)	10 (8.1)	0.991
Pre-existing primary headache diagnosis (%)	14 (24.1)	12 (13.8)	43 (35)	0.002
Pre-existing primary headache intensity	5.5 (5–8.25)	4 (2–5)	6 (4–7)	0.096
Current intensity	5 (4–7.5)	5 (4–7)	7 (6–8)	0.009
Hours/day facial mask usage	6 (4–10)	5 (4–7)	6 (5–7)	0.350
Days/month eye protection usage	9.5 (6.7–20)	20 (12–23)	20 (13–26)	<0.001
Hours/day eye protection usage	5.5 (4–8)	5 (5–7)	6 (5–8)	0.200
Days/month combined facial mask and eye protection usage	10 (6.7–20.5)	20 (12–22)	18 (10–23)	0.001
Hours/day combined facial mask and eye protection usage	5.5 (4–8)	5 (5–7)	6 (5–7)	0.463
Headache intensity associated with PPE		4 (4–5)	7 (6–8)	<0.001
Days/month headache associated to PPE		5 (3–10)	10 (5–15)	<0.001
Months headache associated to PPE		1 (1–2)	2 (1–3)	0.007
Days/month PPE-associated headache medication		1 (0–3)	3 (0–7)	0.003
Resolution time > 1 h <i>n</i> (%)		30 (34.5)	60 (48.8)	0.039
Headache present > 15 days per month <i>n</i> (%)		12 (13.8)	42 (34.1)	0.001
Facial pain <i>n</i> (%)		59 (67.8)	91 (74)	0.425
No usage of analgesics prior usage to PPE <i>n</i> (%)		63 (72.4)	78 (63.3)	0.014
Decreased job performance <i>n</i> (%)		28 (32.2)	65 (52.9)	0.004

Table 6 Multivariable logistic regression analysis of independent factors and PPE usage patterns associated with the development of de novo headache (model 1) and headache with severity moderate to severe (model 2).

Variable	Odds ratio (95% CI) ^a	<i>p</i> value
Model 1 (headache associated with PPE)		
Occupation (other than physician)	1.59 (1.20–2.10)	0.001
Age (> 30 years)	2.54 (1.25–5.14)	0.010
Female sex	3.58 (1.86–6.87)	<0.001
Model 2 (headache moderate to severe)		
Age (> 30 years)	2.18 (1.29–3.68)	0.003
Occupation (other than physician)	2.27 (1.21–4.26)	0.011
Eye protection use (> 2 h)	2.37 (1.20–4.67)	0.012
Migraine	2.80 (1.33–5.92)	0.007

^aModel adjusted for by age, sex, occupation, comorbidities, primary headache, stress, depression and patterns of use of PPE

personnel and others only represent 9% of the population in this report, and maybe this population has the lowest risk due to the shorter time using PPE.

The International Headache Society (IHS) establishes the diagnostic criteria for external-compression headache (Headache Classification Committee of the International Headache Society (IHS) 2018). It is noteworthy that in our study, among the participants who presented compression headache related with PPE use, 39% of the participants presented it after 1 h of PPE use and up to 41% persisted beyond 1 h after PPE removal, characteristics that comply only partly with the current diagnostic criteria for external-compression headache. This differs from the HAPPE study (Ong et al. 2020) where the diagnostic criteria for external-compression headache were met in more than 80% of the individuals studied. More epidemiological studies will be

Table 7 Frequency of different scenarios regarding headache during the 6-month follow-up.

Headache scenario	Frequency <i>n</i> (%)
I did not have headache at the baseline but I have in the last month	27 (16.9)
I did not have headache at the baseline and I do not have in the last month	25 (15.6)
I had headache at the baseline but I do not have in the last month	37 (23.1)
I had headache at the baseline and I have in the last month	71 (44.4)

required to establish with greater precision the proper cutoff of the length of PPE usage in this group of headaches.

Finally, to our knowledge, this is the first study reporting a follow-up for 6 months to evaluate the evolution of these headaches. Clearly, some can evolve to chronic and medication overuse headaches, specially in the presence of stress as a predictive risk factor. In fact, stress is one of the most reported triggers and prognostic factor for migraine and chronic headaches (Vgontzas et al. 2021; Probyn et al. 2017).

Regarding the attention due to this headache, we offer consultation to all participants, 30 participants showed interest and 7 were evaluated in the Neurology department, none of them present red or orange flags for headaches according to the SNOOP10 list and was not required neuroimaging or neither lumbar puncture, of these 7 subjects, two were treated with pericranial nerve block and the rest were treated with acute and preventive medication according to the headache phenotype.

We recognize some limitations of our study. First, we did not perform serial nasopharyngeal swab tests during the survey, and therefore, healthcare personnel with subclinical COVID-19 could have been included, with a secondary headache associated with the infection instead of the PPE use (Membrilla et al. 2020; Poncet-Megemont et al. 2020; Uygun et al. 2020; Seth and Kushwaha 2020; Kristoffersen et al. 2020; García-Azorín et al. 2020). To assess this possibility, we compared participants with SARS-CoV-2-positive tests results with participants with negative tests results, and found no differences in headache frequency or severity. Second, given that the data were collected through the application of surveys, the recall bias cannot be excluded as a modifiable factor in our analyses. Moreover, with our data assessments, we were not able to distinguish with precision the true nature of a PPE-related headache, as either essentially an external-compression headache or just a trigger of primary headaches in susceptible individuals. Other limitations are that some participants use more or less time the PPE that impact the results. Our results are not generalizable to all healthcare workers; depends in the PPE type, time and pattern of use that could be different in other centers.

Conclusion

The frequency of PPE-related headache in COVID-19 healthcare workers is high with risk to evolve to chronic and medication overuse headaches. In addition, the frequency of burdensome-associated symptoms and severity are high, which may impact the quality of life and the quality of care delivered by the affected individuals. We need more epidemiological studies to improve the knowledge of this type of headache and the ways to prevent and treat it.

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Declarations

Conflict of interest The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethic approval and participants consent The Ethics and Research Committees of the Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán approved the study on May 15, 2020 (reference number: 3395), effective from this date to May 15, 2021. All participants signed an informed consent prior to enrollment.

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