Original research

Mask-associated 'de novo' headache in healthcare workers during the COVID-19 pandemic

José María Ramirez-Moreno ,[1,2] David Ceberino,[2] Alberto Gonzalez Plata,[2] Belen Rebollo,[2] Pablo Macias Sedas,[2] Roshan Hariramani,[2] Ana M Roa,[2] Ana B Constantino[2]

[1]Biomedical Sciences, University of Extremadura, Faculty of Medicine, Badajoz, Spain
[2]Neurology, Badajoz University Hospital, Badajoz, Spain

Correspondence to
Dr José María Ramirez-Moreno, Biomedical Sciences, Universidad de Extremadura Facultad de Medicina, Badajoz 06006, Spain; jramrez@unex.es

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ABSTRACT

Objectives The pandemic caused by the new coronavirus (COVID-19) has changed care activities of health professionals. We analysed the possible association between the appearance of 'de novo' headache according to the type of mask used, the related factors and the impact of the cephalalgia on health professionals.

Methods Cross-sectional study in a tertiary hospital in Extremadura, Spain. We provided an online questionnaire to healthcare workers during the period of maximum incidence of COVID-19 in our setting.

Results The subjects are n=306, 244 women (79.7%), with an average age of 43 years (range 23–65). Of the total, 129 (42.2%) were physicians, 112 (36.6%) nurses and 65 (21.2%) other health workers. 208 (79.7%) used surgical masks and 53 (20.3%) used filter masks. Of all those surveyed, 158 (51.6%) presented 'de novo' headache. The occurrence of a headache was independently associated with the use of a filter mask, OR 2.14 (95% CI 1.07 to 4.32); being a nurse, OR 2.09 (95% CI 1.18 to 3.72) or another health worker, OR 6.94 (95% CI 3.01 to 16.04); or having a history of asthma, OR 0.29 (95% CI 0.09 to 0.89). According to the type of mask used, there were differences in headache intensity, and the impact of a headache in the subjects who used a filter mask was worse in all the aspects evaluated.

Conclusion The appearance of 'de novo' headache is associated with the use of filter masks and is more frequent in certain healthcare workers, causing a greater occupational, family, personal and social impact.

Key messages

What is already known about this subject?

- During the increase in COVID-19 cases, health authorities established the mandatory use of Personal Protective Equipment (PPE) by health professionals.
- Face masks are recommended as a simple barrier to help prevent respiratory droplets from travelling through the air and reaching others when the person wearing the mask coughs, sneezes, speaks or raises his voice.
- In 'front-line' work, wearing masks can be time consuming.
- Although highly effective masks are generally well tolerated, some health problems have been reported, including headaches.

What are the new findings?

- The appearance of 'de novo' headache is associated with the use of filter masks and is more frequent in certain health workers, causing a greater occupational, family, personal and social impact.
- The pathogenesis of 'de novo' PPE-associated headaches could possibly have several aetiological considerations, including mechanical factors, hypoxaemia, hypercapnia or stress.

How might this impact on policy or clinical practice in the foreseeable future?

- Given that the use of these devices will tend to become widespread due to the implications of the pandemic, we believe it is important to promote prevention and protection strategies that guarantee the safety of workers, without affecting their quality of life.
- Better strategies may be needed to design various types of PPE and reduce their exposure time for healthcare workers.
- Through engineered solutions, the next-generation protective mask will have an improved design with an emphasis on tolerability and consequently be less prone to headaches.

INTRODUCTION

In December 2019, a new coronavirus, SARS-CoV-2, started an outbreak in the Chinese city of Wuhan. In January 2020 its clinical picture was defined as a disease associated with COVID-19.[1 2] This outbreak evolved into a pandemic and on 24 May 2020, 216 countries had been affected, 5 206 614 cases had been confirmed worldwide and 337 736 deaths.[3] In Spain, there are 233 037 cases, and 27 940 patients have lost their lives.[4] In the region of Extremadura, 3047 cases and 506 deaths have been reported.[5]

During the increase in cases of COVID-19 in our environment, the health authorities established the mandatory use of Personal Protective Equipment (PPE) by health professionals. This PPE consists of a protective suit, surgical gloves, protective goggles, shield and face mask. In the case of face masks, they must be highly effective, with type FFP2 (filtering face pieces) (in Europe), N95 (USA) and KN95 (China) recommended.[6] There are other types of

masks (surgical masks or FPP1 among others), of lesser effectiveness, which are used by healthcare personnel who is not in direct contact with COVID-19.[7]

In 'front-line' work, the use of masks can be very prolonged.[8] Although, in general, highly effective masks are well tolerated, some problems have been reported, such as: general discomfort; decreased visual, auditory or vocal capacity; excessive heat or humidity; facial pressure; skin lesions; itching; fatigue; anxiety and claustrophobia.[9] Another effect described in the 2003 SARS epidemic was headache, whose prevalence reached 37.3% of the health personnel studied.[10] This headache can be related to mechanical factors, the presence of hypoxaemia and hypercapnia or to the stress associated with mask use.[11 12] Our aim is to demonstrate if there is an association between the appearance of 'de novo' headache with the type of mask and its time of use, as well as the impact of this headache on health professionals.

METHOD

The study was conducted in the health area of a tertiary hospital, where our health system in the COVID-19 period urged health professionals to use PPE during contact with patients.

These protective systems were mandatory among health workers, both in high-risk areas, and in general medical wards, central hospital radiology, and diagnostic imaging areas or outpatient clinics. This involved the use of different types of more or less tight-fitting masks, and sometimes glasses or screens.

Using a self-administered questionnaire addressed to health workers in our health area, we carried out a cross-sectional study during the first week of May 2020. In the previous month, the number of admissions for COVID-19 was very high and attendance protocols required the use of these devices by all workers.

Following the International Classification of Headache Disorders, Third Edition (ICHD-3) criteria,[11] we define 'de novo' headache: 'when a new headache occurs for the first time in close temporal relationship to use PPE, even when the headache has the characteristics of a primary headache (migraine, tension type of headache, cluster headache or one of the other trigeminal autonomic headaches)'.

The questionnaire collected the following information: (1) demographics; (2) medical history, including SARS-CoV-2 infection; (3) type and pattern of mask use: surgical masks versus self-filter masks of particles and liquid aerosols (FFP), average number of hours of use per day and use of other protective devices (glasses or screens); (4) frequency and characteristics of pre-existing primary headache (changes in headache frequency, attack duration and frequency, as well as drug use and response); (5) the main variable of the study was personal opinion about the presence of a new headache in the period in which these protective systems were mandatory; (6) presence of other symptoms potentially associated with the use of facial protection equipment; (7) we evaluated the self-perceived impact of the presence of new-onset headache using the Likert scale on social, occupational, family and personal aspects; (8) we also evaluated the self-perceived impact that headache conditions have on the performance of work activities and (9) lastly, we analysed self-perceived work stress by means of the Psychosomatic Problems Questionnaire (PPQ).[13]

The questionnaire was written after an analysis of the literature and a thorough reflection on the problem to be investigated. It included a request for voluntary collaboration, information on the reason for the survey, instructions for completing the questionnaire and consent. The average time taken to complete was about 20 min.

The information collection procedure chosen was the online survey. The survey was scheduled to be conducted over 5 consecutive days, between 1 May 2020 and 6 May 2020, with the data collected referring to the previous month.

The data collected in the study respects the anonymity of the subject and there is no possibility of access to any personal information of the individual. The data analysed are restricted to the study investigators, health authorities and the Ethics Committee, when required, in accordance with current legislation.

STATISTICAL ANALYSIS

Prior to the analysis of relationships between variables, descriptive analyses of the different areas that make up the study have been carried out. These descriptive analyses include percentage distributions of the different categories of the analysed variables and, in the case of quantitative variables, average and SD. These same analyses, shown as a cross between variables by means of contingency tables or comparison of averages, have also been elaborated as a preamble to the statistical tests that have been carried out to corroborate if there is a relationship between different variables, thus showing the hypotheses to be contrasted.

Depending on the nature of the variable and the distribution of the sample, different tests have been used. We used the X^2 test to contrast whether there is independence between two categorical variables using a contingency table when the data are not paired.

For the analysis of the predictive factors with the appearance of a 'de novo' headache, we used binary logistic regression methods by steps backwards, to maximise sensitivity; variables with a univariate association of $p<0.200$ were included as candidates in the multivariate model.

To measure the relationship between the different variables in the study, statistical tests with a 95% significance level were used as an acceptance threshold for the hypotheses to be tested, that is, a p value of 0.05. All statistical analyses were performed using the SPSS V.25.0 statistical package program for Windows.

RESULTS

A total of 306 health professionals and other health workers participated in the study, 62 men (20.3%) and 244 women (79.7%), with an average age of 43 years (SD: 11; range: 23–65). Of these, 129 (42.2%) participants were physicians, 112 (36.6%) nurses and the rest, 65 (21.2%) other health workers (assistants, guards, technicians, administrative staff). With regard to the work shift, 89 (34.1%) worked in the morning and on duty, 91 (34.9%) at morning, afternoon and night shifts, and 81 (31.0%) in morning shifts only. The surgical mask was used by 208 (79.7%) of those surveyed, and the filter mask (FFP2 or KN95) was used by 53 (20.3%), with no difference in the mean time of use 7.0 (SD: 2.3) hours vs 6.7 (SD: 2.5) hours, $p=0.289$. A total of 46.4% (121) reported not habitually using other facial protection devices such as glasses, screens or PPE. The rate of confirmed SARS-CoV-2 infection in the study population was 4.6%.

The most frequently reported diseases in the total sample in order of frequency were: allergy, 34 (13.0%); thyroid diseases, 28 (10.7%); anxiety, 26 (10.0%); high blood pressure, 18 (6.9%); asthma, 17 (6.5%); dyslipidaemia, 14 (5.4%) and diabetes, 2 (0.8%). A total of 15.7% (41) indicated tobacco consumption.

Of the 306 persons surveyed, 158 (51.6%) reported the appearance of a new headache during the period of study, of whom 65 (41.1%) had previously had a headache (migraine: 27 (17.1%), tension: 26 (16.5%) and others: 11 (6.9%)). There

Table 1 Baseline conditions and mask and Personal Protective Equipment (PPE) usage among healthcare workers

		De novo headache		
	Total	No	Yes	
	N= 261	(n=103)	(n=158)	P value
Age, years (SD)	42.9 (10.7)	40.8 (11.4)	44.4 (10.1)	0.009
Female gender	208 (79.7%)	73 (31.1%)	135 (64.9%)	0.004
Occupation				0.0001
Doctor	112 (42.9%)	61(54.5%)	51 (45.5%)	
Nurse	95 (36.4%)	33 (34.7%)	62(65.3%)	
Others	54 (20.7%)	9(16.7%)	45(83.3%)	
Work shift				<0.0001
Mornings and 24-hour duties	89 (34.1%)	51 (57.3%)	38 (42.7%)	
Rotating shifts	91 (34.9%)	26 (28.6%)	65 (71.4%)	
Others	81 (31.0%)	26 (32.1%)	55 (67.9%)	
Type of face mask				0.029
Surgical mask	208 (79.7%)	89 (42.8%)	119 (57.2%)	
N95/FFP2	53 (20.3%)	14 (26.4%)	39 (73.6%)	
Number of hours worn per day (SD)	6.9 (2.3)	6.8 (2.4)	7.0 (2.2)	0.474
Use of another PPE:				0.203
Face shield	54 (20.7%)	21 (38.9%)	33 (61.1%)	
Protective eyewear	33 (12.6%)	13 (39.4%)	20 (60.6%)	
Complete PPE	46 (17.6%)	16 (34.8%)	30 (65.2%)	
Confirmed COVID-19	12 (4.6%)	4 (33.3%)	8 (66.7%)	0.161
Pre-existing headache	110 (42.1%)	45 (40.9%)	65 (59.1%)	0.683
Comorbidity				
Allergy	34 (13.0%)	16 (47.1%)	18(52.9%)	0.331
Asthma	17 (6.5%)	11 (64.7%)	6 (35.3%)	0.028
Tobacco	41 (15.7%)	8 (19.5%)	33 (80.5%)	0.004
Arterial hypertension	18 (6.9%)	9 (50.0%)	9 (50.0%)	0.789
Cardiopathy	1 (0.4%)	0 (0.0%)	1 (100%)	0.419
Dyslipidaemia	14 (5.4%)	7 (50.0%)	7 (50.0%)	0.76
Diabetes	2 (0.8%)	1 (50.0%)	1 (50.0%)	0.76
Thyroid disease	28 (10.7%)	9 (32.1%)	19 (67.9%)	0.402
Anxiety	26 (10.0%)	6 (23.1%)	20 (76.9%)	0.072
Others	16 (6.1%)	4 (25.0%)	12 (75.0%)	0.222
Other symptoms				
Sleep disturbance	79 (30.3%)	11 (13.9%)	68 (86.1%)	0.0001
Loss of concentration	73 (28.0%)	14 (19.2%)	59 (80.8%)	0.0001
Irritability	74 (28.4%)	18 (24.3%)	56 (75.7%)	0.002
Photophobia	31 (11.9%)	8 (25.8%)	23 (74.2%)	0.097
Sonophobia	24 (9.2%)	6 (25.0%)	18 75.0%)	0.128
Sickness/vomiting	24 (9.2%)	11 (45.8%)	13 (54.2%)	0.503

FFP2, filtering face pieces; N95, 95% particle filtering capacity.

were 103 (33.7%) subjects who did not observe the appearance of a new headache. A 14.7% were undecided on the answer 'I don't know' or the answer was 'maybe'; these 45 subjects were eliminated from the analysis.

They were also asked about the presence of other symptoms such as sleep disturbance, loss of concentration, irritability, photophobia, sonophobia, nausea or vomiting. Table 1 shows the characteristics of the population.

During April, the month prior to the survey, participants with 'de novo' headache presented a median of 12 (IQR: 13) days of headache, median of 4 (IQR: 3) days in the week prior to the survey, and the pain presented an average intensity on the Visual Analogue Scale (VAS) of 6 (SD: 1.5). In 74 (47.4%) subjects, the duration was from 1 to 4 hours; in 46 (29.5%), from 4 to 8 hours; in 21 (13.5%), from 8 to 12 hours; and in 15 (9.6%), more than 12 hours. In subjects with previous headache, the duration of episodes was significantly higher (p=0.008). The response to analgesics was good or very good in 61.4% of the cases. Only two (1.3%) subjects had to consult the emergency department for headache, and no subject had been admitted to hospital. With respect to the impact of headache in the work setting, lack of concentration on tasks was the main report (105 (66.5%) subjects). Table 2 shows the main characteristics of 'de novo' headache.

Of the 65 subjects with a previous headache, 83.1% (54) indicated a modification in the characteristics of their habitual headaches, 81.0% (47) a change in location, 67.2% (39) in frequency, 36.2% (21) in intensity and 25.9% (15) in the response to habitual analgesics.

In the univariate analysis, the factors associated with the appearance of 'de novo' headache were age, female sex, type of profession, use of filter mask (KN95 or FFP2), work shift, being

Table 2 Characteristics of headache in healthcare worker (HCW) mask users

	All HCW with de novo headache	HCW without pre-existing headache	HCW with pre-existing headache	
	(n=158)	(n=93)	(n=65)	P value
Days with headache/month (SD)	13.2 (7.2)	13.0 (7.4)	13.5 (7.1)	0.746
Days with headache/week (SD)	3.8 (1.7)	3.8 (1.7)	3.9 (1.7)	0.827
Mean pain level, VAS (SD)	5.9 (1.5)	5.8 (1.5)	6.1 (1.4)	0.08
Duration time (hours)				0.008
1–4	74 (47.4%)	52 (57.1%)	22 (33.8%)	
4–8	46 (29.5%)	23 (25.3%)	23 (35.4%)	
8–12	21 (13.5%)	12 (13.2%)	9 (13.8%)	
>12	15 (9.6%)	4 (4.4%)	11 (16.9%)	
Analgesic response				0.342
Good or very good	97 (61.4%)	61 (65.6%)	36 (55.4%)	
Regular	46 (29.1%)	23 (24.7%)	23 (35.4%)	
Bad or very bad	15 (9.5%)	9 (9.7%)	6 (9.2%)	
Headache impact on HCW (SD)				
Occupational	4.0 (2.6)	3.5 (2.6)	4.6 (2.5)	0.02
Family	4.4 (2.7)	4.1 (2.6)	4.9 (2.5)	0.084
Personal	5.0 (2.6)	4.7 (2.7)	5.5 (2.4)	0.049
Social	4.8 (2.8)	4.4 (2.8)	5.4 (2.7)	0.021

SD, Standar Deviation; VAS, Visual Analogue Scale.

a tobacco user, suffering from anxiety or asthma. In the multivariate analysis, the use of filter masks and the type of profession behaved as independent predictors of headache risk, while being asthmatic behaved as a protective factor. The occurrence of headache is associated with the use of a filter mask (FFP2 or KN95), OR 2.14 (95% CI 1.07 to 4.32); being a health worker, OR 6.94 (95% CI 3.01 to 16.04) or a nurse, OR 2.09 (95% CI 1.18 to 3.72) (table 3).

According to the type of mask used, there was no difference in the number of days with headache in the month prior to the survey, 13.4 (SD: 7.4) vs 12.6 (SD: 6.9); nor in the previous week, 3.9 (SD: 1.6) vs 3.6 (SD: 1.7); but in the intensity according to VAS, 5.7 (SD: 1.5) vs 6.5 (SD: 1.2), p=0.004.

The impact of headache in subjects with a filter mask as opposed to surgical mask was worse in the four aspects evaluated by the Likert scale: occupational, 4.44 vs 3.81 (p=0.206); family, 5.10 vs 4.20 (p=0.065); personal, 5.64 vs 4.84 (p=0.05) and social, 5.46 vs 4.58 (p=0.076) (figure 1). The impact was also greater in subjects with a previous headache in the four aspects evaluated (table 2).

Regarding the evaluation of self-perceived work stress by means of the 12 items of the PPQ, individuals with 'de novo' headache versus those without headache have significantly worse scores in all aspects evaluated, except for the decrease in appetite where no significant differences are observed. Figure 2 shows graphically the evaluation of occupational stress according to the presence of headache or not. The use of a filter mask compared with surgical mask only implies a significantly worse score in two aspects: gastrointestinal discomfort (p=0.047) and greater sensation of extreme tiredness (p=0.004).

DISCUSSION

The current COVID-19 pandemic has caused a substantial change in the workflow of health professionals. One of the most important characteristics has been the use of PPE. Masks are a

Table 3 Univariate and multivariate analysis of factors of baseline conditions

	Univariate analysis			Multivariate analysis		
Variables	OR	95% CI	P valúe	OR	95% CI	P valúe
Age	1.03	1.01 to 1.06	0.009			
Female gender	2.41	1.31 to 4.45	0.005			
Doctor	Ref	Ref	0.0001	Ref	Ref	<0.0001
Nurse	2.25	1.28 to 3.94		2.09	1.18 to 3.72	
Other HCW	5.98	2.67 to 13.4		6.94	3.01 to 16.04	
Filter mask versus surgical	2.08	1.07 to 4.07	0.026	2.14	1.07 to 4.32	0.027
Mornings and 24-hour duties	Ref	Ref	0.0001			
Rotating shifts	3.35	1.81 to 6.23				
Other work shifts	2.83	1.52 to 5.32				
Asthma	0.33	0.12 to 0.92	0.03	0.29	0.09 to 0.89	0.026
Tobacco	3.13	1.39 to 7.01	0.003			
Anxiety	2.34	0.91 to 6.05	0.063			

95%CI, 95% Confidence Interval; HCW, healthcare workers; HCW, healthcare worker; OR, odds ratio; Ref., Reference category.

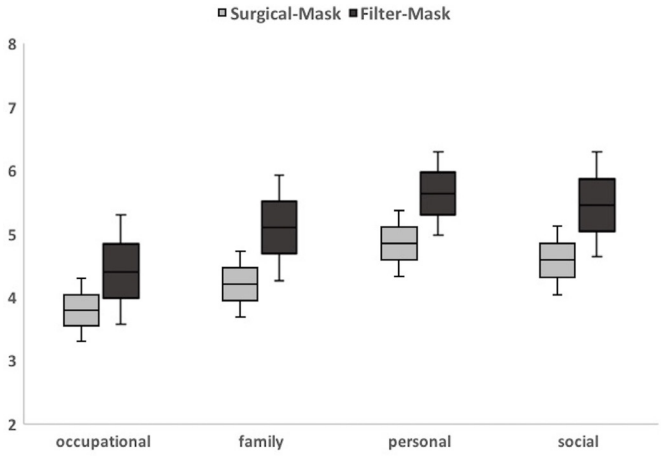

Figure 1 Impact of headache in subjects with a filter mask as opposed to surgical mask in the four aspects evaluated by the Likert scale. Likert scale rating: it indicates the degree of limitation due to headache in different areas of life. 0: none; 10: maximum.

critical preventive measure and are most essential when social distancing is difficult. It is clear that adherence to universal mask policies reduces the transmission of SARS-CoV-2.[14] But, according to the data obtained, we demonstrate a statistically significant association between the use of filter masks and the appearance of headache.

In the physiopathology of a new-onset headache, the exact mechanisms may be multiple, complex and not always well known. Peripheral nociceptive structures and central sensitisation mechanisms may be involved in their development.[15 16] The current International Headache Classification proposes, generically for secondary headaches, that the diagnostic criteria do not require remission or improvement of the underlying causal disorder before the diagnosis is formalised. For acute processes, a close temporal relationship between the onset of the headache and the onset of the suspected causal disorder is usually sufficient.[11] Following this classification, mask-associated headache would probably be a multifactorial disorder with unknown aetiopathogenesis at present. Hypothetically, a number of factors may explain the association with filter mask use, including hypoxia, hypercapnia, local compression and mechanical phenomena, as well as anxiety about wearing the device.[10]

In the scientific literature there are not many studies that relate the use of face masks to changes in the concentration of oxygen and/or carbon dioxide (CO_2), but it seems a plausible hypothesis due to the barrier element that is interposed in the physiological ventilation mechanism.[17] In a Taiwanese cohort of 39 patients with end-stage renal disease who wore N95 masks during the 2002 SARS outbreak, the study found a significant reduction in arterial oxygen pressure from baseline and an increase in other respiratory adverse effects.[18] Another study conducted in a cohort of 130 astronauts subjected to high CO_2 pressures during controlled training showed a significantly

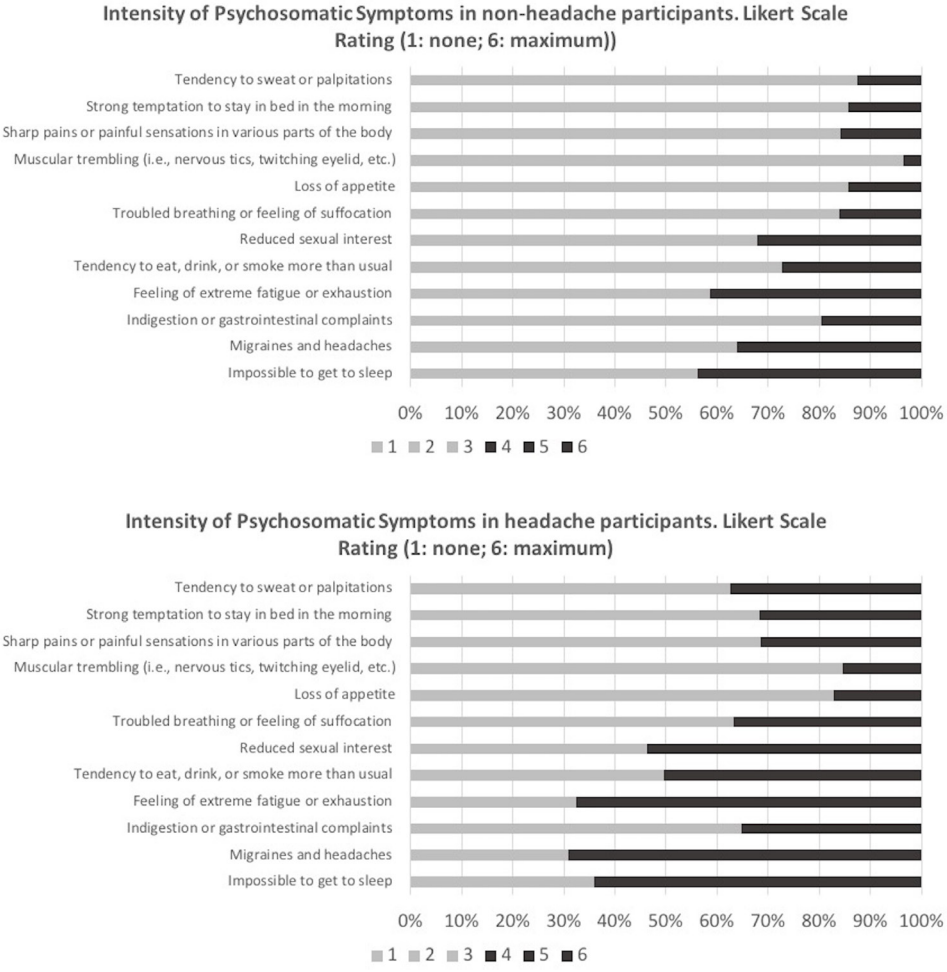

Figure 2 Evaluation of self-perceived work stress by means of the 12 items of the Psychosomatic Problems Questionnaire.

higher incidence of headache in the exposed group, in addition to respiratory symptoms and difficulty in concentrating.[19] At the University of Wollongong, a study on the effects of CO_2 inhalation on workers wearing respiratory protection devices showed that high levels of CO_2 were associated with feelings of discomfort and significantly reduced tolerance and time of device use.[20] The effect on respiratory physiology and muscle performance of wearing training masks designed to simulate a variable altitude situation has been studied. The results are mixed in terms of objective performance parameters, however, it seems that mask use reduces working speed and negatively influences levels of alertness and task focus.[21] In 2014, a pilot study evaluated the consequences on respiratory physiology of surgical mask and N95 face mask use and the extent to which nasal inspiratory and expiratory resistance and discomfort were altered in the individuals. Physiological changes such as increased respiratory resistances were observed after 3 hours of use.[22] Headache associated with filter mask use could be included according to ICHD-3[11] in the section on headaches due to homeostatic disorders where those related to alteration of oxygen and CO_2 partial pressure parameters are included.

Another phenomenon probably related to the physiopathology of headache after PPE use is the external compression that it generates, as recently reflected by the group of Ong *et al*.[23] In most cases there is a temporal relationship between the use of devices and the headache, as well as the topographical location of the headache. As with homeostatic changes, ICHD-3 typifies a type of headache attributable to uninterrupted compression or traction of pericranial soft tissues.[11] Pressure or tractional forces from the mask, together with the accompanying straps, may lead to local tissue damage and exert an irritative effect on the underlying superficial sensory nerves innervating the face, head and cervical region. There are several examples in the literature that would be consistent with this mechanism.[10–24]

The last factor to be mentioned is the level of anxiety or stress. Multiple ways of relating stress and headache have been described, either as 'de novo' or as exacerbation in an individual with primary headache.[25] In the case of the SARS-CoV-2 pandemic, healthcare workers may be affected by critical incident stress (CIS). Critical incidents are events in which people witness or experience tragedy, death, serious injury or threatening situations, which can have a strong emotional impact. The signs and symptoms of CIS can be physical, cognitive, emotional and behavioural.[26] In our work, we observed that the level of stress in subjects with headache is significantly worse in all aspects measured by PPQ.

We also showed that the risk of developing headache is higher among nurses and other health professionals than among physicians. The explanation for this result is complex, but there are three plausible hypotheses. As a general rule, doctors live with a higher level of stress in the course of their work, and therefore, situations considered conflicting do not increase their usual stress threshold excessively.[27] It could also be explained by the use of negative coping strategies in some professional groups as opposed to others[28]; these strategies, not measured in our work, would be related to professional level. The third potential explanation, in line with some published studies, is that the higher risk of headache among nurses and other health professionals than in the medical group, is due to the differential characteristics of the workers' occupation, which would involve the use of other devices, cleaning materials, activities with greater energy expenditure or changing work shifts.[29]

Different factors or comorbidities that may influence the development of headache have been described in the literature.[30] If we look at risk markers, age and sex deserve special attention. The female sex is closely related to the development of 'de novo' headache.[31] Age is a determining factor in the classification of headache according to the International Headache Society.[11] Several studies have shown that pain intensity,[32] the degree of headache disability and the possibility of secondary headache occurrence are age-related factors.[33] In terms of other individually modifiable risk factors, the relationship between blood pressure changes and primary headache should be highlighted, as they share mechanisms of action such as vascular endothelial dysfunction or poor cardiovascular autonomic regulation.[34] However, in our study we did not find a clear association between different comorbidities of the individual and the appearance of headache, except for tobacco consumption in the univariate analysis.

In a review of the relationship between smoking and the occurrence of headache, controversial data were obtained. The studies are mostly retrospective and limited, and there is no definite evidence that tobacco is an independent cause of headache occurrence. However, most patients with migraine define it as a trigger.[35] Headache is one of the most pronounced symptoms in patients suffering from asthma, a fact that has been described in a few papers so far. In a study of 93 patients, a statistically significant difference was found in this area, as 62.4% of asthmatics had headache, whereas in the control group the percentage was only 32.8%. Other factors such as the use of steroid inhalers, the presence of rhinitis, conjunctivitis or respiratory parameters, such as forced expiratory volume in one second, were studied and characterised.[36] In our study, being asthmatic would act as a protective factor against headache associated with mask use, perhaps because of a greater tolerance to hypoxia, and therefore a higher threshold for developing headache for this reason.

It is especially important to discuss possible methods to reduce the impact of PPE-induced headaches. Our findings are in agreement with multiple studies showing that headache triggers are often associated with a change in homeostasis, underscoring the importance of addressing these factors to optimise headache control.[37] For example, encouraging the use of powered air-purifying respirators (PAPRs) is a method for healthcare workers working in high-risk areas and for long periods, since the PAPR provides additional safety and reduces the accumulation of CO_2. On the other hand, we recognise that the conventional N95 face mask fit considers only the overall fit factor and does not take into account the level of tolerability, especially when worn for long periods of time. Since current mask designs can cause headaches and affect compliance, the administrators should think about devising new work schedules for healthcare workers (like shorter working hours) and for people who need to wear a filter mask.[38] Through novel engineering solutions, next-generation face masks need to be better designed with priority on tolerability and less predisposed to headache.

LIMITATIONS

Our study has some limitations that should be noted: the sample is one of convenience and there has been no previous probability sampling. We could not include or under-represent some professional groups. The study is cross-sectional, which helps us to formulate hypotheses, but we cannot prove causality. We have not taken into account the temporal evolution of the headache in the health professionals who present it, nor have we taken into account other external factors that may influence the headache, such as the exact conditions of the site and type of work. The last limitation is that we have not considered other confounding

variables that could potentially condition a headache, such as dehydration due to the continued use of full PPE in a hot environment or lifestyle, or diet changes derived from stress or lack of sleep.

CONCLUSION

In our study, we described the occurrence of 'de novo' headache with the use of filter masks and their negative impact on multiple dimensions of the life of healthcare professionals. We propose headache associated with the use of this type of mask as a new subtype of headache, of a multifactorial nature and complex aetiopathogenesis. Since the use of these devices will tend to become more widespread due to the implications of the pandemic, we believe it is important to promote prevention and protection strategies that guarantee the safety of workers, without undermining their quality of life.

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Contributors JMR-M designed the study, collected data, made statistical analysis plan, wrote the first draft and submitted the manuscript. DC collected data and edited the manuscript for intellectual content. AG-P collected data and edited the manuscript for intellectual content. BR collected data and edited the manuscript for intellectual content. PMS collected data and edited the manuscript for intellectual content. RH collected data and edited the manuscript for intellectual content. AR collected data and edited the manuscript for intellectual content. ABC collected data and edited the manuscript for intellectual content.

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Data availability statement All data relevant to the study are included in the article. No obstante, all the data with which this work has been prepared are available to any researcher upon reasonable and understandable request to the corresponding author.

ORCID iD

José María Ramirez-Moreno http://orcid.org/0000-0001-5061-1510

REFERENCES

1 Zhu N, Zhang D, Wang W, *et al*. A novel coronavirus from patients with pneumonia in China, 2019. *N Engl J Med* 2020;382:727–33.
2 Huang C, Wang Y, Li X, *et al*. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 2020;395:497–506.
3 World Health Organization. *Coronavirus disease (COVID-19) pandemic*. Geneva: WHO, 2020. https://www.who.int/emergencies/diseases/novel-coronavirus-2019
4 National Centre for Epidemiology. *Carlos III Institute of health. current situation COVID 19*. Madrid: CNE-ISCIII, 2020. https://cnecovid.isciii.es/covid19/
5 Ministry of Health of the Regional Government of Extremadura. Health and Social Services. Communication. "Extremadura detects 208 suspected cases of Covid-19, 3 new infections and 3 more deaths". Available: http://www.juntaex.es/comunicacion/noticia&idPub=30300#.Xr1-iC-b7-Y [Accessed 14 May 2020].
6 Garcia Godoy LR, Jones AE, Anderson TN, *et al*. Facial protection for healthcare workers during pandemics: a scoping review. *BMJ Glob Health* 2020;5:e002553.
7 van der Sande M, Teunis P, Sabel R. Professional and home-made face masks reduce exposure to respiratory infections among the general population. *PLoS One* 2008;3:e2618.
8 Sra HK, Sandhu A, Singh M. Use of face masks in COVID-19. *Indian J Pediatr* 2020;1.
9 Shenal BV, Radonovich LJ, Cheng J, *et al*. Discomfort and exertion associated with prolonged wear of respiratory protection in a health care setting. *J Occup Environ Hyg* 2012;9:59–64.
10 Lim ECH, Seet RCS, Lee K-H, *et al*. Headaches and the N95 face-mask amongst healthcare providers. *Acta Neurol Scand* 2006;113:199–202.
11 Headache Classification Subcommittee of the International Headache Society. The International classification of headache disorders, 3rd edition. *Cephalalgia* 2018;38:1–211.
12 Sjaastad O. Headache and the influence of stress. A personal view. *Ann Clin Res* 1987;19:122–8.
13 Hock RR. Professional burnout among public school teachers. *Public Pers Manage* 1988;17:167–89.
14 Brooks JT, Butler JC, Redfield RR. Universal masking to prevent SARS-CoV-2 Transmission-The time is now. *JAMA* 2020;324:635–7.
15 Peng K-P, Fuh J-L, Yuan H-K, *et al*. New daily persistent headache: should migrainous features be incorporated? *Cephalalgia* 2011;31:1561–9.
16 Siberstein SD, Lipton RB, Solomon S, *et al*. Classification of daily and near-daily headaches: proposed revisions to the IHS criteria. *Headache* 1994;34:1–7.
17 Roberge RJ, Coca A, Williams WJ, *et al*. Physiological impact of the N95 filtering facepiece respirator on healthcare workers. *Respir Care* 2010;55:569–77.
18 Kao T-W, Huang K-C, Huang Y-L, *et al*. The physiological impact of wearing an N95 mask during hemodialysis as a precaution against SARS in patients with end-stage renal disease. *J Formos Med Assoc* 2004;103:624–8.
19 Law J, Young M, Alexander D, *et al*. Carbon dioxide physiological training at NASA. *Aerosp Med Hum Perform* 2017;88:897–902.
20 Smith CL, Whitelaw JL, Davies B. Carbon dioxide rebreathing in respiratory protective devices: influence of speech and work rate in full-face masks. *Ergonomics* 2013;56:781–90.
21 Jagim AR, Dominy TA, Camic CL, *et al*. Acute effects of the elevation training mask on strength performance in recreational weight lifters. *J Strength Cond Res* 2018;32:482–9.
22 Zhu JH, Lee SJ, Wang DY, *et al*. Effects of long duration wearing of N95 respirator and surgical facemask: a pilot study. *J Lung Pulm Respir Res* 2014;1:97–100.
23 Ong JJY, Bharatendu C, Goh Y, *et al*. Headaches Associated With Personal Protective Equipment - A Cross-Sectional Study Among Frontline Healthcare Workers During COVID-19. *Headache* 2020;60:864–77.
24 Krymchantowski AV. Headaches due to external compression. *Curr Pain Headache Rep* 2010;14:321–4.
25 Nash JM, Thebarge RW. Understanding psychological stress, its biological processes, and impact on primary headache. *Headache* 2006;46:1377–86.
26 Lowe SR, Bonumwezi JL, Valdespino-Hayden Z, *et al*. Posttraumatic stress and depression in the aftermath of environmental disasters: a review of quantitative studies published in 2018. *Curr Environ Health Rep* 2019;6:344–60.
27 Houle T, Nash JM. Stress and headache chronification. *Headache* 2008;48:40–4.
28 Xu HG, Johnston ANB, Greenslade JH, *et al*. Stressors and coping strategies of emergency department nurses and doctors: a cross-sectional study. *Australas Emerg Care* 2019;22:180–18.
29 Pucci E, Matozzo F, Arrigo A, *et al*. [Prevalence of primary headache related to work activity in a group of hospital workers undergoing periodic visits (D. Lgs. 626/94 s.s.m. ed i.)]. *G Ital Med Lav Ergon* 2003;25:448–52.
30 Jensen R, Stovner LJ. Epidemiology and comorbidity of headache. *Lancet Neurol* 2008;7:354–61.
31 Stovner LJ, Andree C. Prevalence of headache in Europe: a review for the Eurolight project. *J Headache Pain* 2010;11:289–99.
32 Song TJ, Kim YJ, Kim BK, *et al*. Characteristics of Elderly-Onset (≥65 years) headache diagnosed using the International classification of headache disorders, third edition beta version. *J Clin Neurol* 2016;12:419–25.
33 Guido D, Leonardi M, Mellor-Marsá B, *et al*. Pain rates in general population for the period 1991-2015 and 10-years prediction: results from a multi-continent age-period-cohort analysis. *J Headache Pain* 2020;21:52.
34 Guan T, Hu S, Han Y, *et al*. The effects of facemasks on airway inflammation and endothelial dysfunction in healthy young adults: a double-blind, randomized, controlled crossover study. *Part Fibre Toxicol* 2018;15:30.
35 Taylor FR. Tobacco, nicotine, and headache. *Headache* 2015;55:1028–44.
36 Gungen AC, Gungen B. Assessment of headache in asthma patients. *Pak J Med Sci* 2017;33:156–61.
37 Pellegrino ABW, Davis-Martin RE, Houle TT, *et al*. Perceived triggers of primary headache disorders: a meta-analysis. *Cephalalgia* 2018;38:1188–98.
38 Baig AS, Knapp C, Eagan AE, *et al*. Health care workers' views about respirator use and features that should be included in the next generation of respirators. *Am J Infect Control* 2010;38:18–25.