

## RESEARCH ARTICLE

## Factors Associated with the Prevalence of External Compression Headache Attributed to Personal Protection Equipment Usage

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### Abstract

Personal protective equipment (PPE) in the COVID-19 pandemic era is essential for healthcare workers to decrease the risk of infection. The PPE, such as N95 masks and goggles, can trigger external-compression headache (ECH). This study aimed to determine the factors associated with the prevalence of ECH attributed to PPE usage. It was an analytic-observational study with a cross-sectional design conducted at Dr. M. Djamil Hospital Padang in May 2020. The subjects were healthcare workers (doctors and nurses) who used level 3 PPE for a minimum of 4 hours. The diagnosis of ECH was determined by the International Classification of Headache Disorders (ICHD) 3rd edition criteria. The Headache Screening Questionnaire (HSQ) determined the pre-existing primary headaches. The association between variables was analyzed using chi-square and Kruskal-Wallis tests. P value < 0.05 was considered statistically significant. A total of 113 healthcare workers participated in this study, consisting of 46 (40.7%) males and 67 (59.3%) females. The median age was 30 (23–46) years. ECH occurred in 102 (90.3%) respondents. Pre-existing primary headaches were present in 79 (69.9%) respondents, including migraine in 28 (23.6%) and tension-type headaches (TTH) in 46 (40.7%) respondents. The frontalis (69%) and temporalis (50.4%) were the most affected muscles. In this study, the significant factor associated with ECH was pre-existing primary headache (p=0.001, OR=7.795). There was a significant association between the pre-existing TTH (p=0.022) and ECH. There was a non-significant association between pre-existing migraine and ECH (p=0.284). In conclusion, the pre-existing primary headache was associated with the prevalence of ECH attributed to PPE usage.

**Keywords:** External-compression headache, PPE, primary headache

### Introduction

Coronavirus disease-19 (COVID-19) is an acute respiratory syndrome caused by the SARS-CoV-2 and first appeared in Wuhan, China, at the end of 2019.<sup>1</sup> By January 2020, COVID-19 had spread rapidly from Wuhan to other countries. China has reported 80,955 confirmed cases of COVID-19, and more than 37,300 cases have been identified in 113 countries on March 11, 2020.<sup>2,3</sup> World Health Organization reported 1,184,226 confirmed cases with 545,481 deaths worldwide with CFR 4.6% on July 9, 2020. Indonesia declared its first case on March 2, 2020. The cases continue to increase and spread rapidly throughout Indonesia. The Ministry of Health Republic of Indonesia reported 70,736 confirmed cases of COVID-19 with 3,417 deaths (CFR 4.8%) on July 9, 2020.<sup>4</sup>

Healthcare workers are the front-liner in the COVID-19 pandemic. Healthcare workers in all sectors were mandated to wear personal protective equipment (PPE) and follow health

protocols while treating patients with suspected or confirmed COVID-19. The PPE consisted of N95 masks, protective eyewear (goggles or face shield), gowns, surgical gloves, and powered air-purifying respirators (PAPR). The PPE usage for an extended period often causes discomfort or pain.<sup>5,6</sup>

The use of N95 masks and goggles can cause external-compression headache (ECH). The 3<sup>rd</sup> edition of the International Classification of Headache Disorders (ICHD-3) defined ECH as a headache caused by sustained external compression of the pericranial soft tissues due to tools that cause pressure on these areas, such as hats, helmets, and swimming goggles, including N95 masks and goggles.<sup>3,7</sup> ECH is a primary headache not associated with organic extracranial or intracranial disease. It does not require further investigation when the diagnostic criteria are met and the irregular pattern is evident. ECH diagnostic criteria based on ICHD-3 are:<sup>3,7</sup> (1) at least two episodes of headache fulfilling criteria 2–4, (2) brought on by and occurring within one

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hour during sustained external compression of the forehead or scalp, (3) maximal at the site of external compression, (4) resolving within one hour after external compression is relieved, (5) another ICHD-3 diagnosis does not better account for it.

There were still a few studies related to headaches due to the use of PPE, especially N95 masks and goggles are still rare. A previous study in 2003, during the SARS epidemic in Singapore, reported the prevalence of face mask-associated ECH was 37.3%.<sup>8</sup> Recently, research on the prevalence and risk factors of PPE-associated ECH was conducted in Singapore. In this study, the prevalence of ECH was 81.0%.<sup>3</sup> The second-highest prevalence was 51.6% in a study conducted in Spain by Ramirez-Moreno et al.<sup>9</sup> Another study in Morocco reported that PPE-associated ECH was found in 32.9% of healthcare workers.<sup>10</sup> This number was similar to the prevalence reported by Köseoğlu Toksoy et al.,<sup>11</sup> 30.9%. Zaheer et al.<sup>12</sup> concluded the prevalence of PPE-associated ECH in Pakistan was 28.2%, identical to the majority in Italy reported by Rapisarda et al.,<sup>13</sup> which was 26.50%.

Another study involving nurses working in intensive care units reported headache as one of the main factors leading to suboptimal N95 mask-wearing compliance.<sup>14</sup> Previous reports have highlighted pain or discomfort (headache, facial pain, and earlobe discomfort) arising from the tight-fitting of the N-95 mask and its elastic head strap, which confers limited tolerability when used for a long time.<sup>15</sup> This study aimed to determine the factors associated with the prevalence of ECH attributed to PPE usage.

## Methods

It was an observational analytic study with a cross-sectional design conducted at Dr. M. Djamil Hospital Padang in May 2020. Research respondents were healthcare workers (doctors and nurses) who used level 3 PPE for at least 4 hours. The sampling was done by the consecutive sampling method. ECH diagnosis was established based on The International Classification of Headache Disorders, 3<sup>rd</sup> edition (ICHD-3), using a self-administered questionnaire.<sup>7</sup> The pre-existing primary headache was determined based on the Headache Screening Questionnaire (HSQ).<sup>3</sup> The variables examined by the questionnaire included age, gender, body mass index, pre-existing primary headache, the onset

of ECH, and total tenderness score (TTS). HSQ has two scoring algorithms for migraine and tension-type headaches (TTH) based on ICHD-3 diagnostic criteria.

TTS was a scoring system used to assess the tenderness of pericranial tissues. The manual pressure was applied to 8 pairs of muscles and tendon insertions (m. masseter, m. temporalis, m. frontalis, m. pterygoideus lateralis, m. trapezius, m. sternocleidomastoideus, mastoid processes, and occipital muscle insertions). Palpation of the muscles or tendon insertions is done by applying finger pressure while making a small circular motion for 4–5 seconds. Tenderness was scored on a 4-point scale; 0: no visible reaction or verbal report of discomfort, 1: mild mimic reaction but no verbal report of discomfort, 2: verbal report and the mimic reaction of painful tenderness and discomfort, and 3: grimacing or withdrawal, verbal description of aching tenderness. TTS maximum score was 48 (8×2×3) (tender spots at each muscle/tendon insertions × right/left × maximum score).<sup>16,17</sup>

The association between variables was analyzed by chi-square and Kruskal-Wallis tests. The independent variables in this study were age, gender, BMI, and pre-existing primary headache and the dependent variable was the incidence of ECH. P value < 0.05 was considered statistically significant.

The Research Ethics Committee of the Faculty of Medicine Universitas Andalas approved this study with letter number 297/KEP/FK/2020.

## Results

This study was conducted on 113 healthcare workers, consisting of 46 (40.7%) males and 67 (59.3%) females (Table 1). The median age of the respondents was 30 (23–46) years. ECH occurred in 102 (90.3%) respondents. Pre-existing primary headaches were present in 79 (69.9%) respondents, including migraine in 28 (23.6%) and TTH in 46 (40.7%) respondents. Total tenderness score (TTS) is used to assess pericranial tenderness. The median TTS score was 4 (0–20). Based on the location, the frontal muscle was the most affected (69%), followed by the temporal (50.4%), occipital insertion muscles (25.7%), trapezius (20.4%), sternocleidomastoid (11.5%), muscles in mastoid processus (7.1%), masseter (3.5%), and lateral pterygoid (2.7%).

The bivariate analysis was performed to determine the factors associated with ECH

**Table 1** Distribution of Respondents' Characteristics and Baseline Data

Variables	Value
Gender, n (%)	
Male	46 (40.7)
Female	67 (59.3)
Age, years, median (min–max)	30 (23–46)
Body-weight, kg, median (min–max)	60 (43–125)
Height, cm, median (min–max)	160 (145–188)
External-compression headache, n (%)	
Yes	102 (90.3)
No	11 (9.7)
Previous pre-existing primary headache, n (%)	
Migraine	28 (24.8)
Tension-type headaches	46 (40.7)
Migraine and tension-type headaches	5 (4.4)
No history	34 (30.1)
Total tenderness score scale, median (min–max)	4 (0–20)
External-compression headache location, n (%)	
M. masseter	4 (3.5)
M. temporalis	57 (50.4)
M. frontalis	78 (69.0)
M. trapezius	23 (20.4)
M. sternocleidomastoid	13 (11.5)
Occipital muscle insertion	29 (25.7)
Mastoid process	8 (7.1)
Pain intensity scale (visual analogue scale, VAS), n (%)	
Mild headache (1–4)	90 (79.6)
Moderate headache (5–6)	9 (8.0)
Severe headache (7–10)	3 (2.7)

**Table 2** Bivariate Analysis of Factors Associated with the Prevalence of External-Compression Headache

Variables	ECH		OR	95% CI		p*
	Yes	No		Min	Max	
Age (years)						0.742
40	1	0				
<40	101	11				
Gender			0.923	0.254	3.359	0.903
Male	39	7				
Female	63	4				
Body mass index			0.411	0.116	1.458	0.159
Overweight ≥25	26	5				
Normoweight <25	76	6				
Pre-existing primary headaches			7.795	1.923	31.598	0.001
Yes	79	3				
Not	23	8				

Note: \*chi-square,  $p < 0.05$  significant; ECH: external-compression headache

**Table 3 Association between Pre-existing Tension-Type Headache and External-Compression Headache**

Pre-existing Tension-Type Headache	External-Compression Headache				p*
	Yes		No		
	n=102	%	n=11	%	
Yes	49	43.3	1	0.8	0.022
No	53	46.9	10	8.8	

Note: \*Fisher exact test,  $p < 0.05$  significant

**Table 4 Association between Pre-existing Migraine and External-Compression Headache**

Pre-existing Migraine	External-Compression Headache				p*
	Yes		No		
	n=102	%	n=11	%	
Yes	28	24.8	1	0.8	0.284
No	74	65.6	10	8.8	

Note: \*Fisher exact test,  $p < 0.05$  significant

prevalence attributed to PPE usage. The statistical analysis showed that the factor significantly associated with ECH was the pre-existing primary headaches ( $p = 0.001$ ,  $OR = 7.795$ ) shown in Table 2.

There was a significant association between ECH prevalence and pre-existing TTH with a  $p$  value = 0.022 (Table 3). In Table 4, an analysis was carried out to assess the association between

ECH prevalence and pre-existing migraine. There was no significant association found with a  $p$  value = 0.284.

One hundred two respondents who experienced ECH were examined and analyzed to assess the association between the onset of ECH after wearing PPE for several hours and the value of TTS. There was no correlation between the onset of ECH and the value of TTS (Table 5).

In addition, an analysis was conducted to assess the association between the onset of ECH and the type of pre-existing primary headache. There was no significant association found between these variables (Table 6).

**Table 5 Association between Onset of ECH and the Value of TTS**

Crossword Clue		
Onset of ECH	R	-0.023
	P	>0.001*
	n	102

Note: \*Spearman correlation test,  $p < 0.05$  significant

## Discussion

The increase in COVID-19 cases has caused the government to stipulate the mandatory usage of personal protective equipment (PPE)

**Table 6 Association between Onset of ECH and Pre-existing Primary Headache**

Variables	Severity of ECH				p*
	Migraine	TTH	MTTH	Non-MTTH	
Onset ECH, minutes, median (min-max)	30 (5-120)	30 (10-180)	15 (15-120)	60 (10-180)	0.110

Note: \*Kruskal-Wallis test,  $p < 0.05$  significant; ECH: external-compression headache; TTH: tension-type headache; MTTH: Migraine and tension-type headaches

for healthcare workers. This PPE consists of protective clothing, surgical gloves, goggles, and masks. The type of mask used must be effective; the recommended types are FFP2 (in Europe), N95 (US), and KN95 (China).<sup>18</sup> There are other types of masks (surgical masks or FFP1) that are less effective and are used by healthcare workers with no direct contact with COVID-19 patients. Strict usage of PPE is essential because it can decrease viral transmission to healthcare workers and limit the spread of infection from healthcare workers to healthy patients.<sup>9</sup>

This study describes the factors associated with ECH prevalence in healthcare workers at Dr. M. Djamil Hospital Padang, who used level 3 PPE (N95 masks and goggles) during the COVID-19 pandemic. This study found that 90.3% of respondents experienced ECH attributed to PPE usage. Exposure to N95 masks and goggles for at least four hours a day and pre-existing primary headaches are risk factors for ECH. The results of this study are similar to the survey by Ong et al.<sup>3</sup> at the National University Hospital (NUH) Singapore, which found the prevalence of ECH was 77.8%. This ECH prevalence certainly has an impact on occupational health and safety of healthcare workers who work at the front lines in this COVID-19 pandemic.<sup>3,17</sup>

The pathogenesis of ECH attributed to PPE usage involves several causes other than mechanical factors due to compression on pericranial structures, the pain-sensitive organs. Pericranial tenderness also can be triggered by hypoxemia, hypercarbia, and stress due to work during the COVID-19 pandemic.<sup>14,19,20</sup> In this study, an analysis was conducted to determine the factors associated with ECH prevalence. The results showed that pre-existing primary headaches were significantly associated with ECH prevalence ( $p=0.001$ ,  $OR=7.793$ ). It was also in line with research by Ong et al.,<sup>3</sup> which stated that pre-existing primary headaches (migraine and TTH) were the most common conditions for ECH occurrence compared to other comorbidities such as asthma, diabetes, hypertension, and heart disease, and anxiety. Factors such as age, gender, and BMI were not significantly associated with the prevalence of ECH.<sup>3,21,22</sup>

The primary headache subtype analysis was conducted in this study. It was found that the association between pre-existing tension-type headache and the prevalence of ECH was more significant ( $p=0.022$ ) compared to pre-existing migraine ( $p=0.284$ ). This result differed from all

previous studies that reported migraine as the most common pre-existing headaches. Ong et al.,<sup>3</sup> where the pre-existing migraine was more significant than a tension-type headache. We also analyzed the association between the ECH onset and pre-existing primary headache, but no significant association was found.

Anatomically, ECH that occurs due to the use of PPE, in this case, is an N95 mask and protective eyewear or goggles occurs due to pressure from the mask and goggles as well as traction due to the rope on the N95 mask and goggle, which irritates the superficial sensory nerves found on the face, head, and neck (trigeminal nerve, occipital nerve, zygomaticotemporal nerve, etc.). Peripheral sensitization can activate the trigeminocervical complex, sending nociceptive impulses to the trigeminal nerve, then to the brainstem and cortical areas, causing headaches. This reason might explain why respondents who had a previous history of tension headaches were more likely to experience ECH.<sup>23-25</sup>

A study by Ong et al.<sup>3</sup> in Singapore stated that during the COVID-19 pandemic, patients with pre-existing primary headaches experienced increased headaches attacks, for both migraines and TTH, predominantly due to PPE usage. Other factors that also increased headache intensity were the changes in sleep patterns, physical exhaustion, emotional stress, eating late, and dehydration. Further study is needed to investigate the increase of primary headaches attacks due to ECH attributed to PPE usage.<sup>3,16,26</sup>

## Conclusions

This study found that personal protective equipment (PPE) in the COVID-19 pandemic era was associated with external-compression headache (ECH). The most significant factor related to ECH prevalence was a pre-existing primary headache. Tension-type headaches (TTH) prevalence was higher than migraine. The muscle most commonly affected were the frontalis and temporalis muscles.

## Conflict of Interest

There is no conflict of interest in this study.

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