

Headaches Associated with N95 Mask Usage amongst Healthcare Workers in Operating Theatres during COVID-19 Pandemic: A Cross-Sectional Study

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Abstract

Introduction: N95 respirator masks are a cornerstone in the fight against the ongoing COVID-19 pandemic. However, its use has side effects such as headaches. The primary aim of this study is to identify factors that may contribute to higher occurrences of headaches with wearing N95 masks. **Methods:** A cross-sectional study was conducted across healthcare providers in operating theatres of a tertiary hospital based in Singapore involved in the care of COVID-19 patients. The study involved a self-administered online questionnaire completed by all participants. **Results:** 176 participants were included into the study, of which 65 (36.9%) reported headaches associated with wearing N95 masks. Out of the 65 participants who experienced headaches, 28 (43.1%) reported experiencing “*mild*” headache, 30 (46.2%) reported experiencing “*moderate*” headache, and 7 (10.7%) reported experiencing “*severe*” headache. 44 participants (67.7%) reported that the headache has affected their work, and 20 participants (30.8%) required analgesia to relieve the headaches. Other symptoms associated with N95 mask usage include skin damage (12.3%), breathlessness (15.4%), giddiness (6.2%), nausea (6.2%) and ear pain (3.1%). Multivariate logistic regression analysis showed that participants younger than 32 years old ($p = 0.001$) and history of pre-existing headache disorders ($p = 0.001$) were associated with higher occurrences of headaches with wearing N95 masks. **Conclusion:** Our study showed that younger age and history of pre-existing headache disorders con-

tribute to higher occurrences of headaches with N95 mask usage. These associations could be useful in identifying at-risk individuals so that precautions may be taken to reduce the occurrence of headaches when wearing N95 masks.

Keywords

N95 Masks, Headache, COVID-19, Health-Care Workers, Operating Theatre

1. Introduction

Coronavirus disease 2019 (COVID-19), an infectious disease by a coronavirus strain SARS-CoV-2, was declared a pandemic by the World Health Organization (WHO) in March 2020 [1]. Healthcare workers possess a significant risk of contracting COVID-19, attributed by the nature of their work requiring close proximity to patients either suspected or confirmed to be infected with COVID-19. WHO recommends that healthcare workers wear N95 respirator masks at all times in health facilities during aerosol-generating procedures [2]. Many healthcare institutions in Singapore, including Changi General Hospital (CGH), mandates the use of N95 respirator masks in the operating theatres [3] [4] [5] [6].

However, the use of N95 respirator masks is not without its challenges. One of the most dominating issues with prolonged tight-fitting N95 mask usage is the occurrence of headaches from the sustained compression of pericranial soft tissues [7] [8] [9] [10] [11]. The Headaches Associated with Personal Protective Equipment (HAPPE) study conducted in 2020 showed that majority of healthcare workers develop *de novo* associated headaches or exacerbation of their pre-existing headache disorders [12]. On the global stage, there have been five similar studies published that investigated the effect of headache sustained by healthcare workers related to Personal Protective Equipment (PPE) use during the COVID-19 pandemic, and showed that a history of pre-existing headache disorders predisposes the user to a higher risk of headaches when using N95 masks [9] [13] [14] [15] [16]. However, there has been no similar study conducted surveying healthcare workers based in operating theatres. We hypothesize that factors, such as history of pre-existing headache disorders, can contribute to headaches with use of N95 masks in the operating theatres and negatively affect the user's work performance. The primary aim of this study is to identify the factors that may contribute to higher occurrence of headaches with use of N95 mask. The secondary aim is to investigate the impact of headaches on the users' work and other side effects or complications that had resulted from the increased N95 mask usage.

2. Methods

We conducted a cross-sectional study across healthcare workers in operating

theatres at CGH during the COVID-19 pandemic between the period of June 2020 to August 2020. CGH is a tertiary level care hospital in Singapore that provides medical care to patients infected with the COVID-19 infection. Institutional guidelines from CGH mandates all healthcare workers to wear National Institute of Occupational Safety and Health (NIOSH)-certified N95 respirator masks in the operating theatres, and for all staff had to undergo N95 mask fitting tutorials and tests. The three models of N95 masks that are approved for use in CGH are 3M 1860/1860S, 3M 1870+ and 3M 8210.

The study participants were invited to complete a self-administered online survey written in English through an email broadcast. The study population included all healthcare workers (doctors, nurses and allied health staff) aged 21 years or older who work in the operating theatres of CGH. Demographic data (gender, age, occupation, history of pre-existing headache disorders) and data specific to N95 masks (N95 mask model, average duration of N95 wearing in a day, occurrence of headache with N95 mask usage, severity of headache) were collected. The severity of headache was measured using pain scores from the Visual Analogue Scale, and the survey included a section for participants to state whether they required any painkiller relief and to score how much the headache, if any, has affected their work using the 5-point Likert scale. Aside from headache, the survey also required participants to describe any other side effects from wearing the N95 mask. The participants' average daily duration of wearing N95 mask was recorded based on either being more than 4 hours, or less than 4 hours as per the HAPPE study [12].

Statistical Analysis

Our primary aim was to identify factors that have an association with the occurrence of headache with increased N95 mask usage. All demographic and survey data were summarized with respect to the occurrence of headache with increased N95 mask usage. Continuous variables were summarized either as mean with standard deviation (SD) or median with interquartile range (IQR) and range, and categorical variables were summarized as frequency with proportion. Univariate and multivariable logistic regression models were used to identify possible risk factors of headache with increased N95 mask usage. The significance level was set at 0.05 and all tests were two-tailed. Data were analysed using Stata version 16 (StataCorp LP, College Station, TX, USA).

3. Results

A total of 191 participants were surveyed, of which 15 participants were excluded from the study for incomplete and irregular data. The demographics and survey results of the remaining 176 participants are shown in **Table 1**. 65 (36.9%) participants reported an occurrence of headache with an increased N95 mask usage during this COVID-19 pandemic period, with 48 (73.9%) of them having to wear the N95 mask for more than 4 hours.

Table 1. Characteristics of 176 participants categorized based on occurrence of headaches with increased N95 usage. Values are expressed as n (%) unless otherwise stated.

Characteristics	Occurrence of headaches with increased N95 usage		Total (n = 176)
	Yes (n = 65)	No (n = 111)	
Age (years), mean (SD)	(n = 62) 29.6 (5.45)	(n = 102) 34.4 (8.77)	32.6 (8.01)
Age groups			
<32 years old	42 (67.7)	44 (43.1)	86 (52.4)
≥32 years old	20 (32.3)	58 (58.9)	78 (47.6)
Occupation			
Doctor	35 (53.8)	52 (46.8)	87 (49.4)
Nurse	9 (13.8)	14 (12.6)	23 (13.1)
Operating Theatre staff	21 (32.3)	45 (40.5)	66 (37.5)
Gender			
Male	5 (7.7)	21 (18.9)	26 (14.8)
Female	60 (92.3)	90 (81.1)	150 (85.2)
Type of N95 mask			
3M 1860/1860S	47 (72.3)	81 (73.0)	128 (72.7)
3M 8210	5 (7.7)	8 (7.2)	13 (7.4)
3M 1870+	13 (20.0)	22 (19.8)	35 (19.9)
Hours wearing N95 mask			
<4 hours	17 (26.2)	29 (26.1)	46 (26.1)
≥4 hours	48 (73.9)	82 (73.9)	130 (73.9)
Pre-existing headache	16 (25.4)	9 (8.3)	25 (14.5)
VAS pain score, median (IQR [Min - Max])	4.0 (3 - 6 [1 - 10])		
Having to take analgesia to relieve headache	20 (30.8)		20 (11.4)
“Headaches have affected my work”			
Strongly agree	6 (9.2)		6 (3.4)
Agree	38 (58.5)		38 (21.6)
Neutral	16 (24.6)		16 (9.1)
Disagree	5 (7.7)		5 (2.8)
Strongly disagree	0		0
Other symptoms			
Skin damage	8 (12.3)	19 (17.1)	27 (15.3)
Shortness of breath	10 (15.4)	34 (30.6)	44 (25.0)
Giddiness	4 (6.2)	6 (5.4)	10 (5.7)
Nausea	4 (6.2)	0	4 (2.3)
Ear pain	2 (3.1)	1 (0.9)	3 (1.7)

VAS: Visual Analogue Scale.

Figure 1 shows the severity of headache experienced by participants who reported an occurrence of headache with an increased use of N95 mask. Participants were categorized based on their self-reported pain scores from the Visual Analogue scale, with “mild” being VAS pain scores 0 - 3, “moderate” for VAS pain scores 4 - 6, and “severe” for VAS pain score 7 - 10. 28 (43.1%) participants reported experiencing “mild” headache, 30 (46.2%) participants reported experiencing “moderate” headache, and 7 (10.7%) participants reported experiencing “severe” headache. The median (IQR [Min - Max]) VAS pain scores were 4 (3 - 6 [1 - 10]). Out of the 65 participants who reported occurrence of headache, 44 participants (67.7%) agreed that the headaches have affected or severely affected their work, and 20 participants (30.8%) needed to take analgesia to relieve the headaches. Aside from the headaches, other common symptoms experienced by participants include shortness of breath (25.0%), skin damage such as skin tears, acne and eczema (15.3%), giddiness (5.7%) and nausea (2.3%).

Table 2 shows the univariate and multivariate logistic regression analyses of factors associated with occurrence of headaches with increased N95 mask usage

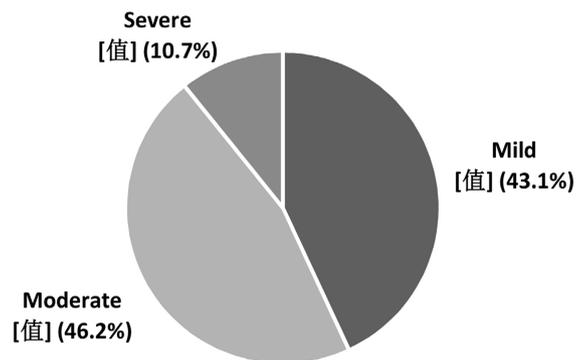


Figure 1. Pie chart illustrating the severity of headache experienced by the 65 participants who reported occurrence of headaches with increased N95 mask usage. Values are expressed as n (%).

Table 2. Univariate and multivariate logistic regression analysis of covariates of headache with N95 mask usage.

Characteristics	Unadjusted OR (95% CI)	P-value	Adjusted OR (95% CI)	P-value
Age (Ref: ≥ 32 years old)	1.018 (0.357 - 1.679)	0.003	3.733 (1.741 - 8.004)	0.001
Female gender (Ref: Males)	2.800 (1.001 - 7.832)	0.050	3.200 (0.975 - 10.500)	0.055
Hours wearing N95 mask (Ref: <4 hours)	0.999 (0.498 - 2.004)	0.997	1.150 (0.508 - 2.605)	0.737
Pre-existing headache (Ref: Negative)	3.783 (1.558 - 9.185)	0.003	7.775 (2.381 - 25.396)	0.001

in the COVID-19 pandemic. Factors that show an independent association with occurrence of headache include participants younger than 32 years of age ($p = 0.001$) and history of pre-existing headache disorders ($p = 0.001$). Interestingly, wearing N95 mask for more than 4 hours did not show a correlation with the occurrence of headache incurred during increased N95 mask usage in our study ($p = 0.737$).

4. Discussion

Prior to this study, there have only been two local studies analysing headaches its association with PPE use. The first study was conducted in March 2006, based off the 2003 Severe Acute Respiratory Syndrome (SARS) epidemic, [10] and the other being the HAPPE study performed in March 2020 in the midst of the current COVID-19 pandemic [12]. These studies were conducted on healthcare workers in inpatient wards and the emergency department. No prior study has been conducted surveying healthcare workers based in operating theatres.

In our study, participants with a history of pre-existing headache disorder were more likely to experience headaches with N95 mask usage. Our findings are similar to those found in published studies [10] [12] [14]. The rationale for this correlation is still poorly understood and could be due to a multitude of reasons such as peripheral sensitization from the pre-existing headache disorder, the hypoxemia or hypercarbia incurred from N95 mask usage acting as a trigger for the pre-existing headaches, and the associated stress, inadequate hydration and irregular meal times that arose from the pandemic [17] [18] [19]. It is imperative that users with pre-existing headache disorders are vigilant in addressing potential triggers for headaches to reduce the risk of sustaining one during N95 mask usage.

Participants younger than 32 years of age are more likely to experience a headache with N95 mask usage. We hypothesize two possible explanations for this association. First, it has been shown that the perception of pain changes with age. Younger individuals were reported to have lower pain thresholds as compared to their older counterparts [20] [21]. Hence, it is possible that the younger participants in the study population are more sensitive to the pain and discomfort sustained with N95 mask usage. Second, the prevalence of primary headache disorders increases with younger age [22]. Hence, the use of N95 mask may have aggravated these symptoms.

Interestingly, we did not find a statistically significant correlation between the duration of N95 mask usage and occurrence of headaches. The occurrence of headaches can largely be attributed to mechanical factors and the associated hypercarbia and hypoxemia from the increased airway resistance that N95 masks unfortunately cause. Proper and effective usage of N95 masks requires them to be tightly fitted onto the user, which can cause pressures on the local soft tissues and superficial sensory nerves, leading to headaches [11] [23]. Moreover, alterations in respiratory physiology from N95 mask usage can lead to changes in ce-

rebral blood flow and subsequently development of headaches [24]. That being said, our findings are not in keeping with those made by published local studies [10] [12]. A possible explanation could be the temporal relationship between the period users started to wear N95 masks and the period the studies began. In the HAPPE study, the cross-sectional study was conducted shortly after the surge in COVID-19 cases in the country and the call for increased PPE usage, which included N95 mask usage, when caring for suspected or confirmed COVID-19 patients. Hence, it is possible that users were not used to this practice of increased N95 mask usage. Conversely, our study was conducted approximately three months after the call for increased PPE usage was made, giving users more time to become more accustomed with increased N95 mask usage. Only 30.8% of our study participants who had headaches with N95 mask usage felt the need to take painkillers to relieve the pain, a finding which is in congruence with that made by the HAPPE study [12].

Aside from headache, other symptoms such as dyspnea, skin breakdown, giddiness and nausea were experienced by participants with increased N95 mask usage. The onset of these symptoms is also related to the mechanical and ventilatory factors that come with N95 mask usage and reported in published studies [10] [12] [13] [24]. Altogether, these have led to a significant negative impact on participants' work as seen in 67.7% of our study population. In the face of a pandemic that does not seem to be relenting, the prolonged and increased use of N95 mask in the healthcare facility will likely to be sustained, if not intensify, in the near future. Dissatisfaction from N95 mask usage could have devastating ramifications on the user's occupational productivity, quality of life and psychological outlook in the long term. Therefore, it would be worthwhile to invest in strategies to avoid the adverse impacts of N95 mask usage such as having shorter duty shifts or a better design of the respirator mask that not only purports efficacy in filtering out the virus but also has better user comfort.

Our study is not without limitations. Recall bias cannot be fully eliminated in this self-administered questionnaire. There may be selection bias as the majority of our respondents were of a younger age group. This may not be fully representative of the target population. The sample size of our study is small which may affect the accuracy of the results. Additionally, we cannot prove causality in this cross-sectional study, and cohort studies to investigate predictive models may be the next step forward in addressing this. Lastly, we did not take into account external factors which could contribute to a headache, such as the use of eye-wearing goggles or other PPE, type of work and burden or presence of non-work stressors in the participant.

Moving forward, there may be a role to further explore the specifics of how work performance in the healthcare workers in operating theatres has been affected. Objective indicators could potentially include duration taken for surgeries or the duration taken to prepare the operating theatre for the next incoming case in-between cases. Additional measures can also be taken by the respective

departments to explore ways to alleviate these adverse events associated with PPE use while adhering to the safety precautionary measures, essential in the current pandemic.

5. Conclusion

The use of N95 mask in the operating theatres is likely going to be a lasting measure in the fight against the COVID-19 pandemic. However, it is fraught with complications such as headaches and reduced user satisfaction. Our study has identified younger age and history of pre-existing headache disorders to be potential associations with the occurrence of headaches with N95 mask usage. Further studies are needed to establish the causality of these potential risk factors, and if utilising these risk factors to identify at-risk individuals likely to develop headaches and take measures to safeguard their wellbeing.

Declarations

The Singhealth Centralised Institutional Review Board approval was obtained prior to the commencement of the study (Singhealth CIRB Ref: 2020/2548). The study does not contain data from any individual person. The datasets during and/or analysed during the current study are available from the corresponding author on reasonable request. The authors declare that they have no competing interests. THLT, JLL and LWL conceptualized and designed the study. DJAT and LWL analysed the data and wrote the manuscript. All authors read and approved the final manuscript. The authors would like to thank Ms. Pei Ting Tan (statistician) for her contributions to the statistical analysis of the data.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Questionnaire: Headaches Associated with PPE Use (In OT)

Section 1:

- 1) Which department in CGH do you work in?
- 2) What is your role/job scope? (E.g. Nurse, doctor)
- 3) What is your age?
 - Free text
- 4) What is your gender?
 - Male/Female
- 5) Have you been wearing PPE (E.g. N95, protective goggles) on a more frequent basis since the implementation of the recent COVID-19 pandemic?
 - Yes/No
- 6) How many hours a day do you don PPE?
 - <1 hour
 - 1 - 2 hours
 - 2 - 4 hours
 - 4 - 6 hours
 - 6 hours or more
- 7) Do you have any pre-existing headache disorders?
 - Yes/No
- 8) Do you experience headaches when donning PPE?
 - Yes/No
 - If yes, please proceed to section 2
 - If no, please proceed to section 3

Section 2: (I experience headaches when donning PPE)

- 1) How frequently have these headaches occurred?
 - Once a week
 - 3x per week
 - >6 times per week
- 2) On a scale of 0 - 10, 0 being no pain and 10 being the worst pain experienced in your life, could you rate the severity of these headaches?
 - Score __
- 3) If you have a pre-existing headache disorder, do you feel that donning PPE has increased the frequency and/or severity of these headaches?
 - Yes/No
- 4) Do you take any analgesia for relief of these headaches?
 - Yes/No
- 5) Do you take any preventive analgesia to prevent the onset of these headaches?
 - Yes/No
- 6) These headaches have affected my work performance
 - Strongly disagree
 - Disagree
 - Neutral

- Agree
- Strongly agree

Section 3: (I do not experience headaches when donning PPE)

1) Are there any symptoms, besides from headaches, that you experience when donning PPE

- Free text

2) These symptoms have affected my work performance

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree