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The association of face mask use with self-reported cardiovascular symptoms during the COVID-19 pandemic

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ABSTRACT

Introduction: Countries are mandating the use of face masks to stem the spread of COVID-19. Face mask use has been associated with discomfort due to its effects on thermoregulation, breathing and oxygenation. We evaluated the prevalence and severity of self-reported cardiovascular symptoms before and during face mask use.

Methods: This was a cross-sectional study of 1001 participants residing in Singapore, who participated in a self-administered questionnaire between 25th April 2020 to 4th May 2020. Symptom severity before and during mask use and health-seeking behaviour information were collected. The study outcome was the self-reported worsening of cardiovascular symptoms, and its association with the type of mask worn, duration of mask worn per day, and intensity of physical activities during mask use.

Results: The commonest symptom reported during mask use was dyspnoea. Independent predictors for self-reported cardiovascular symptoms during mask use were moderate–high physical activity during mask use (OR 1.634, 95% CI 1.176–2.270, p=0.003), duration of mask use ≥3 hours (OR 1.672, 95% CI 1.189–2.352, p=0.003) and the type of mask used, after adjusting for age, sex, healthcare-based worker status and presence of comorbidities. N95 mask was associated with worse symptoms when compared to surgical mask. Participants with ≥3 worsening symptoms, or worsening dyspnoea, palpitations, fatigue and dizziness were more likely to seek medical help.

Conclusion: Face mask use is proven to be an effective way in curbing COVID-19 transmission. However, participants in this study had concerns regarding its use and these concerns should be urgently addressed to enable mask-use policies to be enacted.

Keywords: cardiovascular symptoms, COVID-19, face mask use

INTRODUCTION

The rapid global spread of the coronavirus disease 2019 (COVID-19) has seen an increase in the use of face masks for personal protection, either in hospital-based settings or when in public spaces. On 31st January 2020, there were 16 reported positive COVID-19 cases in Singapore, with an increasing overall number of cases to more than 58,000 to date (3rd November 2020). The government has since distributed surgical and cloth masks in a bid to prevent community spread, and has mandated mask use in public spaces from 14th April 2020 onwards.[1-5] A similar strategy of universal mask use has been adopted by more than 120 countries worldwide.[6] The Centers for Disease Control and Prevention has recommended the use of face masks as an additional precautionary measure in public settings.[7]

Face mask use has previously been associated with wearer discomfort and poor compliance in both the general population and in healthcare workers.[7-10] A study of N95 face mask use by healthcare professionals demonstrated an increase in de novo personal protective equipment (PPE)-associated headaches or exacerbation of existing headache disorders.[11] Face mask use has also been shown to be associated with physiological changes. Surgeons wearing surgical masks during major surgeries had a decrease in oxygen saturation and an associated rise in heart rate post-operation compared to pre-operative baseline values. The extent of decrease in oxygen saturation of haemoglobin correlated with the increased duration of operation.[12] However, the association of face mask use and cardiovascular symptoms are unclear.

As such, with the mandatory use of face masks during the COVID-19 pandemic, it is crucial to understand how face mask use is associated with self-reported cardiovascular symptoms. This has potential implications on mask compliance, physical health and potentially diagnostic testing with further increased strain on the already stretched healthcare systems as governments seek to implement mask-use policies. With the mandatory use of face mask, and

from our anecdotal experiences from specialist clinics, we hypothesize that face mask use would be associated with more self-reported cardiovascular symptoms. We also sought to evaluate the self-reported healthcare-seeking behaviour of these individuals experiencing cardiovascular symptoms related to mask use.

METHODS

This was a cross-sectional study which employed convenience sampling and was conducted from 25th April 2020 to 4th May 2020. The online survey was distributed to personal contacts, via social media and through mailing lists. The study was conducted when face mask use was made compulsory in Singapore to the general population when outside of their homes. The study was open to participants aged ≥ 21 years who were residing in Singapore.

The online questionnaire was self-administered and conducted in English. The questionnaire comprised of six sections which included information on 1) demographics, 2) past medical history, 3) medication list, 4) type and duration of face mask use, 5) physical activity, 6) presence of cardiovascular symptoms before and during mask use, and 7) health-seeking behaviour (Supplementary material 1). Healthcare workers who worked in a healthcare-based setting were also identified. Participants documented severity of chest pain according to the Canadian Cardiovascular Society (CCS) functional status classification of Class I, II, III or IV[13] and dyspnoea according to the New York Heart Association functional status classification of Class I, II, III or IV.[14] The severity of the remaining seven symptoms were scored as none, mild, moderate to severe.

The extent of physical activity was measured with the internationally validated International Physical Activity Questionnaire – short version (IPAQ-short), that has been tested for validity and reliability for national population-based prevalence studies of participation in physical activity. It consists of 4 generic items in quantifying vigorous, moderate, walking and

sitting activities, which allows internationally comparable standards of comparison on health-related physical activity. Metabolic equivalent minutes (MET minutes) for each category of physical activity were summed up to give the total MET minutes of physical activity a week. This was categorised into low, moderate and high physical activity on the IPAQ-short score.[15]

The study evaluated self-reported cardiovascular symptoms before and during mask use. We investigated the presence of worsening symptoms during mask use compared to before mask use. The primary study outcomes are the association between self-reported symptoms, and the type of mask worn, duration of mask worn per day, and the intensity of physical activities during mask use. Worsening symptoms was defined as an increase in intensity of any magnitude of any symptoms during mask use, compared to baseline intensity before mask use.

Categorical variables were expressed as number (percentage) and continuous variables expressed as mean values (±1 standard deviation). Pearson's chi-squared tests (or Fisher's Exact Test, where appropriate) were used to examine categorical variables, while Student's t-tests were used to evaluate continuous variables. Univariable and multivariable logistic regression analysis was performed to identify independent factors associated with a composite measure of worsening symptoms. The multivariable logistic regression model included sex, age, moderate to high physical activity, duration of mask use (≥3 hours), presence of comorbidities, and type of mask (cloth, surgical and N95 face mask). As studies on the association of face mask and symptoms have used surgical masks as their reference, this study chose surgical face mask as the reference for the type of mask used in the multivariable model.[8,12] A p-value of less than 0.05 was deemed significant for this study. All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp, Armonk, NY)

The institutional review board exempted the study from full review as the research involved a survey without identifiers (NHG DSRB reference number: 2020/00445). Implied consent was provided by participants when they took part in the study.

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RESULTS

One-thousand and one respondents participated in this study. A majority of the participants were Chinese (88.0%), the mean age was 41.4 (±14.5) years with a female majority (68.6%). Most of the participants were non-smokers (93.7%). Healthcare setting-based workers accounted for 47.3% of the participants. The physical activity during mask use, based on the IPAQ-short scoring system, was low in 78.1% of participants, moderate in 19.8% and high in 2.1%.

In terms of type of mask used, 69.7% wore surgical masks, 26.6% wore cloth masks, and the remaining 3.7% wore N95 face masks. A large proportion of participants wore masks for ≥3 hours per day (47.7%). About a third of the participants (33.9%) had medical comorbidities, with hyperlipidaemia (15.6%) being the most prevalent. The baseline characteristics of the study participants are displayed in Table 1.

The most common reported cardiovascular symptoms were dyspnoea (395, 39.5%), fatigue (359, 35.9%), palpitations (215, 21.5%) and dizziness (158, 15.8%) during mask use. Similarly, the most common symptoms that increased in severity during mask use were dyspnoea (34.5% of study population had worsening breathlessness), followed by fatigue (33.0%) and palpitations (19.0%).

Overall, 532 participants (53.1%) reported worsening of symptoms during face mask use. One hundred and thirty-two (13.2%) participants reported worsening of 2 symptoms, 95 (9.5%) reported worsening of 3 symptoms and 110 (11.0%) reported worsening of ≥4 symptoms. Statistically significant increase in severity of all symptoms except leg swelling was found during mask use compared to baseline before mask use (Table 2). In particular, there was significant self-reported worsening of chest pain (9.6% vs 2.4%, p<0.001) and dyspnoea (39.5% vs 5.8%, p<0.001) during mask use compared to before mask use.

Compared to wearers of surgical masks, wearers of N95 masks experienced statistically significant worsening of palpitations (OR 2.244, 95% CI 1.097 – 4.588, p=0.027), fatigue (OR 3.757, 95% CI 1.878 – 7.513, p<0.001), dizziness (OR 2.805, 95% CI 1.366 – 5.760, p=0.005) and fainting spells (OR 5.020, 95% CI 2.045 – 12.324, p<0.001). There was no difference in worsening of cardiovascular symptoms between participants wearing surgical versus cloth masks.

As the largest proportion of the study population (47.7%) agreeing that ≥3 hours of mask use per day was associated with the development of cardiovascular symptoms, we used ≥3 hours of mask use per day as the threshold for comparison. Mask use of ≥3 hours per day was associated with worsening dyspnoea (53.9% vs 46.1%, p=0.004), palpitations (54.7% vs 45.3%, p=0.030), fatigue (59.1% vs 40.9%, p<0.001) and dizziness (56.1% vs 43.9%, p=0.026) compared to mask use of <3 hours per day.

On multivariable logistic regression analysis, the use of N95 face mask (OR 2.275, 95% CI 1.030 – 5.020, p=0.042), the duration of face mask use of ≥3 hours per day (OR 1.672, 95% CI 1.189 – 2.352, p=0.003), and moderate to high physical activity during face mask use (OR 1.634, 95% CI 1.176 – 2.270, p=0.003) were found to be independent predictors of self-reported worsening cardiovascular symptoms after adjusting for sex, age, healthcare setting-based worker, and the presence of comorbidities (Table 3 and Figure 1).

Two weeks prior to the study period, 3.1% of participants sought medical treatment for cardiovascular-related symptoms and 0.3% of participants required hospital admission for cardiac-related conditions.

Of the participants who experienced cardiovascular symptoms, 331 (33.1%) reported that they would seek medical help, while 354 (35.4%) would self-monitor their symptoms as they felt that the symptoms were most likely related to mask use (Figure 2).

Seven hundred and eighty-two (78.1%) participants reported that they would observe their symptoms for ≤3 days before seeking medical help. Participants who were more likely to seek medical help included those who reported worsening symptoms during face mask use (OR 2.572, 95% CI 1.962 – 3.373, p<0.001), and those who reported worsening of ≥3 symptoms (OR 2.005, 95% CI 1.397 – 2.876, p<0.001). Participants with dyspnoea (OR 2.163, 95% CI 1.607 – 2.911, p<0.001), palpitations (OR 1.493, 95% CI 1.048 – 2.128, p=0.026), fatigue (OR 2.438, 95% CI 1.793 – 3.315, p<0.001) and dizziness (OR 1.653, 95% CI 1.107 – 2.469, p=0.014) were more likely to seek medical help.

DISCUSSION

There has been increasing evidence that face mask use is an effective strategy in mitigating the spread of COVID-19.[16] Our study describes the association of face mask use with self-reported cardiovascular symptoms. The main findings of our study are: 1) The most common cardiovascular symptoms reported during face mask use were dyspnoea, fatigue and palpitations 2) Moderate to high physical activity during face mask use, duration of mask use ≥3 hours and the use of N95 masks were independent predictors of worsening cardiovascular symptoms during face mask use 3) Close to a third of the study population would seek medical help if they experienced cardiovascular symptoms, with 78.1% of participants willing to observe their symptoms for ≤3 days before seeking help.

Dyspnoea was the most common symptom reported by our study population. Dyspnoea severity worsened during mask use. These findings are in line with published reports on breathing difficulties with surgical mask use in 38% of adults,[8,17] and a significant increase in perception of increased breathing resistance when using both surgical masks and filtering face piece respirators.[8,18] A possible explanation for this is that the use of face mask during physical activities may result in a reduction in oxygen saturations and hence an increase in stress to the heart. A study on surgeons with surgical masks during major surgeries demonstrated a decrease in oxygen saturation with an increase in heart rate. The extent of decrease in oxygen saturation correlated with the duration of operation.[12] Another study on participants with face mask undergoing treadmill exercises found an increase in heart rate, respiratory rate, transcutaneous carbon dioxide and increased mask dead space apparent heat index.[8] During face mask use, exhaled carbon dioxide may be trapped together with heat and moisture, which can decrease blood oxygenation. Furthermore, the masks may also cause a component of airway resistance.[12,19] Another reason for the increased perception of breathlessness may be due to thermal intolerance due to face mask,[8,18,20] although it has been found that this thermal impact may be minimal if face masks were worn over a short period of 1 hour at a low to moderate work load.[8,21] This increase in mean core temperature may be related to the increased energy expenditure to overcome the breathing resistance of the face masks, which may interfere with respiratory heat exchange and heat dissipation from the skin.[8,22]

Another symptom described in current literature during mask use is the physiological responses in heart rate. Roberge et al. found a significant increase in heart rate of 9.4 beats-per-minute in those wearing surgical masks compared to those without.[8] This would be in keeping with our present findings of an increased perception of palpitations during face mask use.

The worsened self-reported severity of cardiovascular symptoms during face mask use was associated with the prolonged duration and high resistance face mask used. Studies on healthcare workers with different types of face masks while performing usual work duties over a 7-hour period found that the perceptions of heat and moisture were significantly stronger with N95 face masks compared to surgical face masks.[8,23,24] Another recent study found that N95 face mask use was associated with PPE-associated headaches when the N95 face mask with protective eyewear were used for ≥4 hours per day. This also affected the perceived overall performance of healthcare workers.[11] Another study found that the increase in heart rate associated with face masks depended on the type of mask used, with significant increase in heart rate demonstrated in those with full-face respiratory protective equipment, compared to those with half face and valve respiratory protective equipment.[25] In the case of surgical masks, the breathing resistance have also been described to be lower than other personal face masks due to the loose fit to the face, which may explain the lower prevalence of worsening symptoms in those wearing surgical masks.[8,26]

Some studies have suggested that the face mask intolerance may be attributed to the discomfort associated during mask use. For example, discomfort may stem from psychological reactions secondary to highly thermosensitive area of the face underneath the mask, rather than symptoms associated with exertion.[8,27] The unpleasant sensation of having the mask sticking to the face during respiration may translate into emotional responses that can be associated with breathlessness and increased respiratory rate.[8,27] These factors in relation to its consequent physiological and psychological impact may have also led to intolerance and noncompliance to face mask use.[28] However, these assumptions were mainly theoretical. Our study did not find any significant association between worsening symptoms and previous anxiety and depression (p=0.410). Nevertheless, the impact of psychological stressors from face mask used, resulting in anxiety and claustrophobia cannot be ignored.[29]

Although our current findings reveal an association of increased self-reported cardiovascular symptoms with face mask use, it is crucially important to emphasise that face mask use remains an effective strategy in dampening the COVID-19 pandemic curve. It has been demonstrated that in cities in the United States mandating the use of face mask, the daily growth rate of COVID-19 cases has been suppressed.[16] As such, the results of this study suggest the need for ongoing research into making masks as comfortable as possible while still being effective barriers to droplet transmission, understanding the implications and health-seeking behaviour of patients in settings with face-mask mandates, and rationalising the healthcare resources available to deal with the pandemic. Studies involving measurement of cardiovascular, respiratory and haematological parameters before and during mask use, as well as epidemiological studies examining the actual health-seeking behaviour of mask-users with cardiovascular symptoms may be helpful. Future prospective studies are needed to examine the association between self-reported worsening cardiovascular-related symptoms due to face mask use and underlying cardiovascular disease. This unmasking of symptoms may be useful in triaging these patients for further in-depth evaluation. This relationship needs to be urgently clarified to optimise the continued need to prevent the spread of COVID-19, and the timely provision of appropriate care for patients with cardiovascular symptoms.

We acknowledge several limitations of our study. Firstly, we did not study the different cloth and surgical masks models which may affect comfort level. Nevertheless, we did account for different mask types (N95, surgical and cloth). Secondly, other factors such as psychological stress in the current pandemic manifesting as somatic sensations mimicking cardiovascular symptoms was not assessed in this study.[30,31] Thirdly, the study results may be affected by recall bias. Fourthly, the study did not capture the number of people invited to participate, and hence we are unable to report the survey response rate. Due to a convenience

sampling method, the results may be limited in generalizability, although we did have a large sample size of respondents.

In conclusion, the use of face mask remains an effective strategy in mitigating COVID-19 transmission. This study highlights that the use of face mask can be associated with more self-reported cardiovascular symptoms. Our findings raise awareness amongst healthcare providers, researchers and policy makers regarding face-mask associated symptoms and its potential implications on health-seeking behaviours of these patients.

REFERENCES

1. Ministry of Health, Singapore. Three more confirmed imported cases of Wuhan coronavirus infection in Singapore. Available at: https://www.moh.gov.sg/news-highlights/details/three-more-confirmed-imported-cases-of-wuhan-coronavirus-infection-in-singapore-31-jan. Accessed May 5, 2020.
2. Ministry of Health, Singapore. 23 more cases discharged; 120 new cases of COVID-19 infection confirmed. Available at: https://www.moh.gov.sg/news-highlights/details/23-more-cases-discharged-120-new-cases-of-covid-19-infection-confirmed.Accessed May 5, 2020.
3. People's Association, Singapore. About 3.52 million reusable masks collected during second wave of mask collection exercise. Available at: https://www.sgpc.gov.sg/sgpcmedia/media_releases/pa/press_release/P-20200409-1/attachment/PA%20Media%20Statement%20on%20Update%20of%20Mask%20Collection.pdf. Accessed May 5, 2020.
4. World Health Organization. WHO characterizes COVID-19 as a pandemic. 11 March 2020. Available at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen. Accessed May 5, 2020.

5. Tay TF. Coronavirus: Mandatory for all in Singapore to wear mask when out, except for kids under 2 and those doing strenuous exercise. In: The Straits Times 2020 Apr 14. Available at: https://www.straitstimes.com/singapore/coronavirus-mandatory-for-all-to-wear-a-mask-when-out-with-exceptions-for-kids-under-2-and. Accessed May 5, 2020.
6. McKie R, Tapper J. With 120 countries making masks compulsory in public, shouldn't England? In: The Guardian 2020 Jul 11. Available at: https://www.theguardian.com/world/2020/jul/11/with-120-countries-making-masks-compulsory-in-public-shouldnt-england. Accessed November 1, 2020.
7. US Centers of Disease Control and Prevention. Guidance for wearing masks. Available at: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/cloth-face-cover-guidance.html. Accessed November 1, 2020.
8. Roberge RJ, Kim JH, Benson SM. Absence of consequential changes in physiological, thermal and subjective responses from wearing a surgical mask. Respir Physiol Neurobiol 2012; 181:29-35.
9. MacIntyre CR, Cauchemez S, Dwyer DE, et al. Face mask use and control of respiratory virus transmission in households. Emerg Infect Dis 2009; 15:233-41.
10. Radonovich LJ Jr, Cheng J, Shenal BV, Hodgson M, Bender BS. Respirator tolerance in health care workers. JAMA 2009; 301:36-8.
11. 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.
12. Beder A, Büyükkoçak Ü, Sabuncuoğlu H, Keskil ZA, Keskil S. Preliminary report on surgical mask induced deoxygenation during major surgery. Neurocirugia (Astur) 2008; 19:121-6.

13. Campeau L. Grading of angina pectoris. Circulation 1976; 54:522-3.

14. Criteria Committee of the New York Heart Association. Nomenclature and Criteria for Diagnosis of Diseases of the Heart and Great Vessels. 9th ed. Boston: Little, Brown and Company, 1994: 253-6.

15. International Physical Activity Questionnaire. Guidelines for data processing and analysis of the International Physical Activity Questionnaire (IPAQ) – short and long forms. Revised November 2005. Available at: https://sites.google.com/site/theipaq/scoring-protocol. Accessed November 1, 2020.

16. Lyu W, Wehby GL. Community use of face masks and COVID-19: Evidence from a natural experiment of state mandates in the US. Health Aff (Millwood) 2020; 39:1419-25.

17. Canini L, Andréoletti L, Ferrari P, et al. Surgical mask to prevent influenza transmission in households: a cluster randomized trial. PLoS One 2010; 5:e13998.

18. Li Y, Tokura H, Guo WP, et al. Effects of wearing N95 and surgical facemasks on heart rate, thermal stress and subjective sensations. Int Arch Occup Environ Health 2005; 78:501-9.

19. Beck WC. The air permeability of surgical masks. Guthrie Clin Bull 1964; 34:26-30.

20. Hayashi C, Tokura H. The effects of two kinds of mask (with or without exhaust valve) on clothing microclimates inside the mask in participants wearing protective clothing for spraying pesticides. Int Arch Occup Environ Health 2004; 77:73-8.

21. Harber P, Bansal S, Santiago S, et al. Multidomain subjective response to respirator use during simulated work. J Occup Environ Med 2009; 51:38-45.

22. Roberge RJ, Kim JH, Coca A. Protective facemask impact on human thermoregulation: an overview. Ann Occup Hyg 2012; 56:102-12.

23. Guo YP, Li Y, Wong TG, et al. Evaluation of different PPE ensembles in terms of sensation, usability, satisfaction and preference. J Fiber Bioeng Inform 2009; 2:126-36.
24. Roberge RJ, Coca A, Williams WJ, Powell JB, Palmiero AJ. Physiological impact of the N95 filtering facepiece respirator on healthcare workers. Respir Care 2010; 55:569-77.
25. Khodarahmi B, Dehghan H, Motamedzadeh M, Zeinodini M, Hosseini S. Effect of respiratory protection equipments wear on heart rate in different workload. Int J Env Health Eng 2013; 2:26.
26. Enerson DM, Eisenfeld LI, Kajikuri H. Heat and moisture trapping beneath surgical face masks: a consideration of factors affecting the surgeon's discomfort and performance. Surgery 1967; 62:1007-16.
27. Williams M, Carafella P, Olds T, Petkov J, Frith P. Affective descriptors of the sensation of breathlessness are more highly associated with severity of impairment than physical descriptors in people with COPD. Chest 2010; 138:315-22.
28. Johnson DF, Druce JD, Birch C, Grayson ML. A quantitative assessment of the efficacy of surgical and N95 masks to filter influenza virus in patients with acute influenza infection. Clin Infect Dis 2009; 49:275-7.
29. Wu S, Harber P, Yun D, et al. Anxiety during respirator use: comparison of two respirator types. J Occup Environ Hyg 2011; 8:123-8.
30. Chew NWS, Lee GKH, Tan BYQ, et al. A multinational, multicentre study on the psychological outcomes and associated physical symptoms amongst healthcare workers during COVID-19 outbreak. Brain Behav Immun 2020; 88:559-65.
31. Tan BYQ, Chew NWS, Lee GKH, et al. Psychological impact of the COVID-19 pandemic on health care workers in Singapore. Ann Intern Med 2020; 173:317-20.

FIGURES AND TABLES

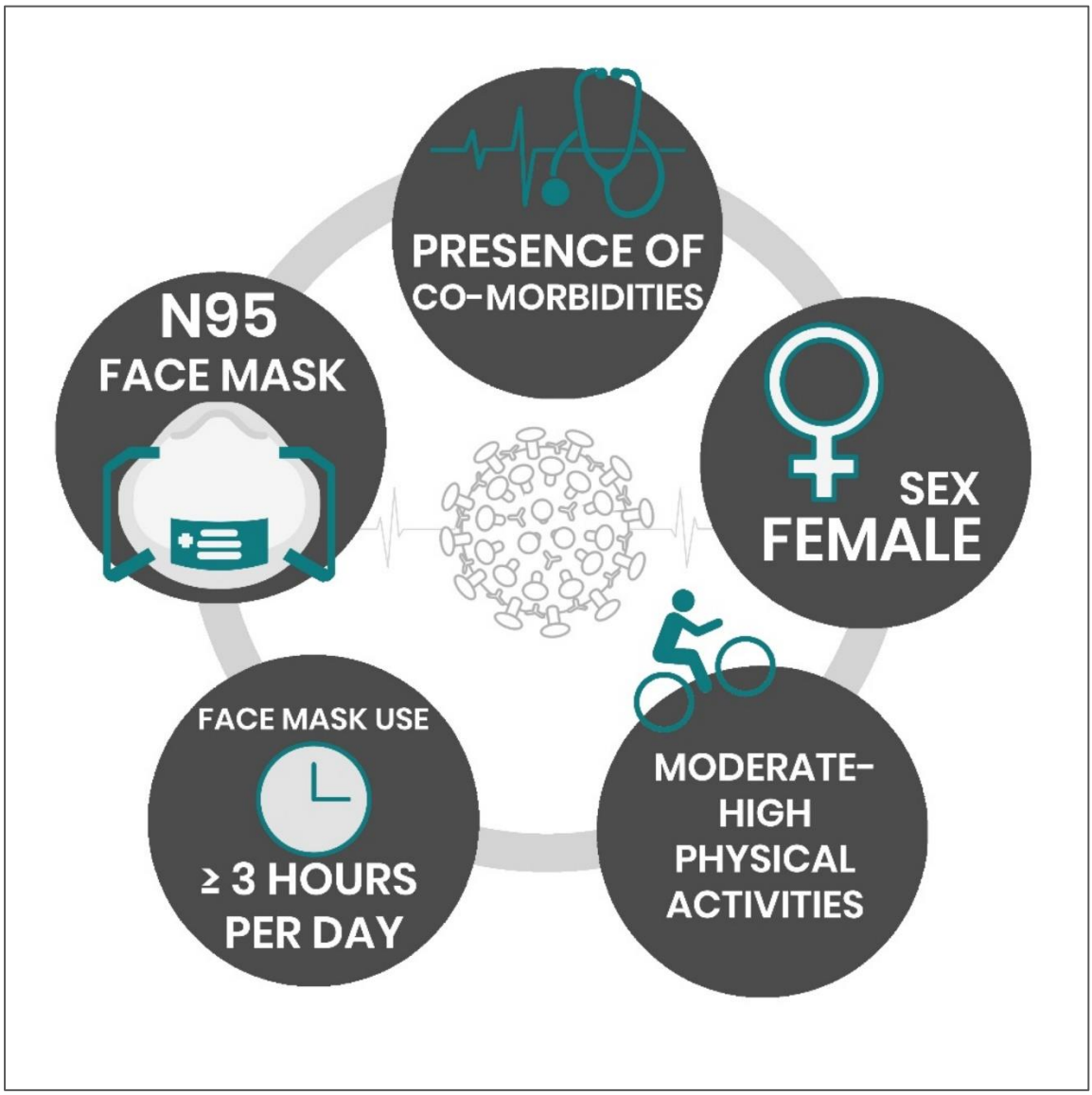

Figure 1. Independent predictors of worsening cardiovascular symptoms during face mask use during the COVID-19 pandemic.

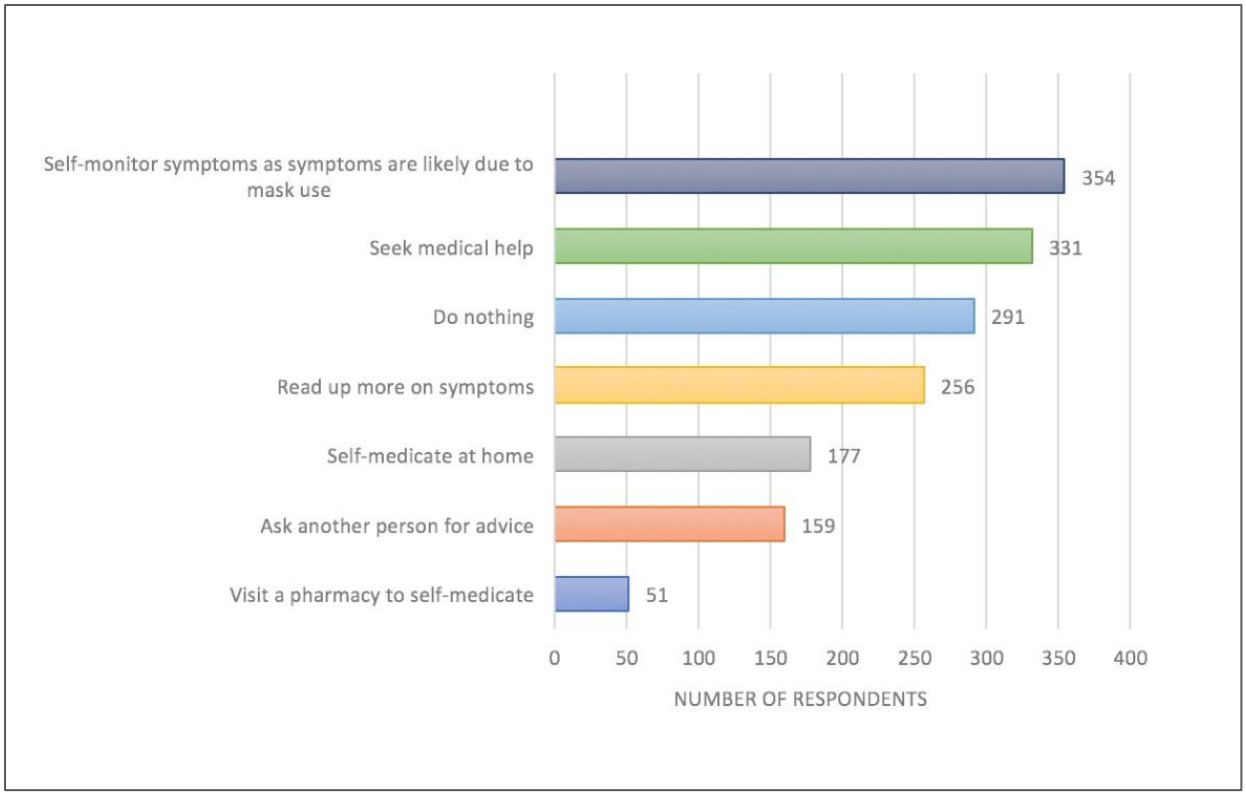

Figure 2. Number of respondents for each self-reported health-seeking behavior in the presence of cardiovascular symptoms. Participants could choose one or more options. (n=1001)

Table 1. Baseline characteristics of study population (N=1001)

Variable	**n (%)**
Age, years	41.4±14.5
Sex, female	687 (68.6)
Ethnicity	
Chinese	881 (88.0)
Malay	34 (3.4)
Indian	38 (3.8)
Eurasian	7 (0.7)
Caucasian	4 (0.4)
Others	37 (3.7)
Marital Status	
Single	426 (46.7)
Married	544 (54.3)
Divorced	19 (1.9)
Separated	3 (0.3)
Widowed	9 (0.9)
Smoking	
Current	21 (2.1)
Ex-Smoker	42 (4.2)
Non-Smoker	938 (93.7)
Occupation	
Government	467 (46.7)
Private/Self-employed	328 (32.8)
Retired/Not working	129 (12.9)

Student	77 (7.7)
Healthcare-based worker	473 (47.3)
Housing Type	
1-room flat	9 (0.9)
2-room flat	23 (2.3)
3-room flat	86 (8.6)
4-room flat	257 (25.7)
5-room flat	228 (22.38)
Condominium	250 (25.0)
Landed housing	148 (14.8)
Education	
Primary	5 (0.5)
Secondary	105 (10.5)
Tertiary	890 (88.9)
No formal education	1 (0.1)
Physical Activity	
High	21 (2.1)
Moderate	198 (19.8)
Low	782 (78.1)
Type of mask use	
Cloth	266 (26.6)
Surgical	698 (69.7)
N95	37 (3.7)
Duration of mask use per day, hours	
0	98 (9.8)
1	288 (28.8)
2	138 (13.8)
≥3	477 (47.7)
Co-Morbidities	
Hypertension	121 (12.1)
Hyperlipidaemia	156 (15.6)
Diabetes	50 (5.0)
Myocardial infarction	8 (0.8)
Heart failure	1 (0.1)
Atrial fibrillation	19 (1.9)
Other heart disease	30 (3.0)
Asthma	67 (6.7)
Chronic obstructive pulmonary disease	3 (0.3)
Obstructive sleep apnea	20 (2.0)
Other lung disease	3 (0.3)
Cancer	21 (2.1)
Anxiety	22 (2.2)
Depression	18 (1.8)
Medications	
Anti-hypertensives	118 (11.8)
Cholesterol medications	130 (13.0)
Diabetes medications	46 (4.6)
Cardiac medications	29 (2.9)
Inhalers	34 (3.4)
Health-Seeking Behaviour	
Visits to any healthcare sector in past 2 weeks	31 (3.1)
Hospital admission for cardiac-related problems in past 2 weeks	3 (0.3)

Threshold of duration of observing symptoms prior to seeking medical attention, days	
<1	173 (17.3)
1	228 (22.8)
2	199 (19.9)
≥3	401 (40.0)

Continuous variables presented as mean ± 1 standard deviation
Categorical variables presented as number (percentage)

Table 2. Differences in the severity of cardiovascular symptoms before and during mask use (N=1001)

Variable	Before mask use	During mask use	P value
Chest pain/discomfort			
Mild activity	11 (1.1)	40 (4.0)	<0.001
Moderate activity	7 (0.7)	41 (4.1)	
At rest	6 (0.6)	15 (1.5)	
Dyspnea			
Mild activity	14 (1.4)	160 (16.0)	<0.001
Moderate activity	32 (3.2)	205 (20.5)	
At rest	12 (1.2)	30 (3.0)	
Palpitations			
Mild	42 (4.2)	176 (17.6)	<0.001
Moderate	6 (0.6)	39 (3.9)	
Severe	0 (0.0)	0 (0.0)	
Nausea			
Mild	5 (0.5)	89 (8.9)	<0.001
Moderate	1 (0.1)	6 (0.6)	
Severe	1 (0.1)	1 (0.1)	
Fatigue			
Mild	47 (4.7)	285 (28.5)	<0.001
Moderate	8 (0.8)	65 (6.5)	
Severe	1 (0.1)	9 (0.9)	
Dizziness			
Mild	15 (1.5)	136 (13.6)	<0.001
Moderate	0 (0.0)	21 (2.1)	
Severe	0 (0.0)	1 (0.1)	
Fainting or near fainting			
Mild	5 (0.5)	46 (4.6)	<0.001
Moderate	0 (0.0)	8 (0.8)	
Severe	0 (0.0)	0 (0.0)	
Cold sweats			
Mild	14 (1.4)	49 (4.9)	<0.001
Moderate	0 (0.0)	2 (0.2)	
Severe	0 (0.0)	0 (0.0)	
Leg swelling			
Mild	8 (0.8)	9 (0.9)	0.406
Moderate	2 (0.2)	3 (0.3)	
Severe	0 (0.0)	0 (0.0)	

Table 3. Univariable and multivariable logistic regression analysis for worsening cardiovascular symptoms during face mask use (N=1001).

	Univariable		Multivariable	
Characteristics	**Odds Ratio (95% Confidence Interval)**	**P-value**	**Odds Ratio (95% Confidence Interval)**	**P-value**
Sex (Female)	1.683 (1.286 – 2.203)	<0.001	1.621 (1.223 – 2.149)	0.001
Age	0.980 (0.972 – 0.989)	<0.001	0.979 (0.968 – 0.990)	<0.001
Physical activity (moderate to high)	1.950 (1.427 – 2.664)	<0.001	1.634 (1.176 – 2.270)	0.003
Mask use (≥3 hours)	1.963 (1.525 – 2.526)	<0.001	1.672 (1.189 – 2.352)	0.003
Healthcare-based worker	1.753 (1.363 – 2.254)	<0.001	1.036 (0.723 – 1.485)	0.846
Presence of comorbidities	0.945 (0.727 – 1.228)	0.672	1.465 (1.074 – 1.998)	0.016
Type of mask				
N95 face mask	2.742 (1.275 – 5.896)	0.010	2.275 (1.030 – 5.020)	0.042
Cloth face mask	0.881 (0.664 – 1.169)	0.381	1.240 (0.902 – 1.704)	0.186
Surgical mask	Reference		Reference	

APPENDIX

Supplementary Material 1. Questionnaire on the association of face mask use with self-reported cardiovascular symptoms during the COVID-19 pandemic.

A. Demographic information

A1. Age (in years)	
A2. Gender	1. Male 2. Female
A3. Ethnicity	1. Chinese 4. Eurasian 2. Indian 5. Caucasian 3. Malay 6. Others
A4. Marital status	1. Single 4. Divorced 2. Married 5. Widow 3. Separated
A5. Occupation	1. Government 4. Student 2. Private/self-employed 5. Not working 3. Retired
A6. Do you work in healthcare sector	1. Yes 2. No
A6. Smoking	1. Current 3. Non-smoker 2. Ex-smoker
A7. Housing	1. 1-room flat 5. 5-room flat 2. 2-room flat 6. Condominium 3. 3-room flat 7. Landed housing 4. 4-room flat

B. Mask Type

B1. Type of mask	1. Cloth 2. Surgical 3. N95
B2. Duration of mask worn / day	1. None 2. 1-hour 3. 2-hours 4. 3-hours or more

C. Past Medical history

1. High blood pressure	1. Yes 0. No
2. High cholesterol	1. Yes 0. No
3. Diabetes	1. Yes 0. No
4. Previous Heart attack	1. Yes 0. No
5. Heart failure	1. Yes 0. No
6. Irregular heart rate (atrial fibrillation)	1. Yes 0. No
7. Other heart problems	1. Yes 0. No
8. Asthma	1.Yes 0. No

9. Chronic obstructive pulmonary disease (COPD) 1. Yes 0. No
10. Obstructive sleep apnea (OSA) 1. Yes 0. No
11. Other lung problems 1. Yes 0. No
12. Cancer 1. Yes 0. No
13. Anxiety 1. Yes 0. No

D. **Medications**

1. Blood pressure lowering medications 1. Yes 0. No
2. Cholesterol lowering medications 1. Yes 0. No
3. Diabetes 1. Yes 0. No
4. Heart Medications 1. Yes 0. No
5. Inhalers 1. Yes 0. No

E. Physical activity while wearing a mask in the last 7 days

Refer to International Physical Activity Questionnaire website: https://sites.google.com/site/theipaq/questionnaire_links

F. Symptoms before and after mask use in the last 4 weeks

Symptoms	**Before Mask Use**	**After Mask Use**
F1. Chest Pain/Discomfort	0. Symptoms while at rest 1. Symptoms with mild activity (<2 blocks or <1 flight of stairs) 2. Symptoms with moderate activity (>2 blocks or >1 flight of stairs) 3. None	0. Symptoms while at rest 1. Symptoms with mild activity (<2 blocks or <1 flight of stairs) 2. Symptoms with moderate activity (>2 blocks or >1 flight of stairs) 3. None
F2. Shortness of Breath	0. Symptoms while at rest 1. Symptoms with mild activity 2. Symptoms with moderate activity 3. None	0. Symptoms while at rest 1. Symptoms with mild activity 2. Symptoms with moderate activity 3. None
F3. Palpitations (Awareness of heart beat)	1. None 3. Moderate 2. Mild 4. Severe	1. None 3. Moderate 2. Mild 4. Severe
F4. Nausea	1. None 3. Moderate 2. Mild 4. Severe	1. None 3. Moderate 2. Mild 4. Severe

F5. Tiredness	1. None 3. Moderate 2. Mild 4. Severe	1. None 3. Moderate 2. Mild 4. Severe
F6. Dizziness	1. None 3. Moderate 2. Mild 4. Severe	1. None 3. Moderate 2. Mild 4. Severe
F7. Fainting or near-fainting	1. None 3. Moderate 2. Mild 4. Severe	1. None 3. Moderate 2. Mild 4. Severe
F8. Cold sweats	1. None 3. Moderate 2. Mild 4. Severe	1. None 3. Moderate 2. Mild 4. Severe
F9. Leg swelling	1. None 3. Moderate 2. Mild 4. Severe	1. None 3. Moderate 2. Mild 4. Severe

G. Health seeking behavior

G1. Recent visit to any healthcare sector in past two weeks for the above physical symptom	1. Yes 2. No
G2. Did you require hospital admission	1. Yes 2. No
G3. How long would you observe symptoms before seeking medical attention	1. 1 day 3. 3 days 2. 2 days 4. 4 or more days
G4. Given the symptoms you have reported, would you (Choose all that apply):	1. Seek medical help 2. Visit a pharmacy to self-medicate 3. Self-medicate at home 4. Self-monitoring symptoms as symptoms are likely due to mask use 5. Read up more on symptoms 6. Ask another person for advice 7. Do nothing