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## **Systematic review on prevalence and factors associated with breathlessness due to face masks in Asian countries**

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**Abstract**--The usage of face masks has been of abundant and daily wear to every single population steeping high when the COVID-19 pandemic transmits airborne. The masks have been said to cause uneasiness and affect the performance of one's daily living activities. Therefore, this study aims to identify the prevalence and factors associated with breathlessness due to face masks in Asian countries. Materials and Methods: Two main journal databases were adopted for this review and the study was done based on the PRISMA flow diagram. After being reviewed for stringent inclusion and exclusion criteria, the data was retrieved and compiled. Quality assessment was done using Newcastle-Ottawa Quality Assessment Scale (NOS). Results: Initial results search accounts for a total of about 800 articles to be reviewed. After eliminating duplication of articles with inclusion and exclusion criteria, we were left with nine articles. Our study shows that there is a high prevalence of breathlessness (26-100%)

upon the usage of face masks with types of masks and duration of usage as its factors. Conclusion: Further studies are needed to infer the relationship between the type and duration of face mask usage with breathlessness. All in all, the production of face masks must be improvised and well suited to the current generation.

**Keywords**---Adults, Asia, face mask, prevalence, factors of breathlessness.

## Introduction

Face masks are a tool of either textile, surgical, or respiratory that is widely used in an effort to limit the spread of airborne viral infections (Dbouk & Drikakis, 2020). MacIntyre, et al, (2009) in their studies mentioned that face masks are used as a non-pharmaceutical intervention in order to control the transmission of viruses during a pandemic. The American Thoracic Society defines breathlessness (dyspnoea) as 'a subjective experience of breathing discomfort that consists of qualitatively distinct sensations that vary in intensity' (Parshall, et al, (2012), 'Difficulty in breathing', 'disordered or disorganised breathings' and 'uncomfortable awareness of breathing' are other keywords commonly associated with the meaning of breathlessness (Shiber, et al, 2006 and Bass, et al, 1990).

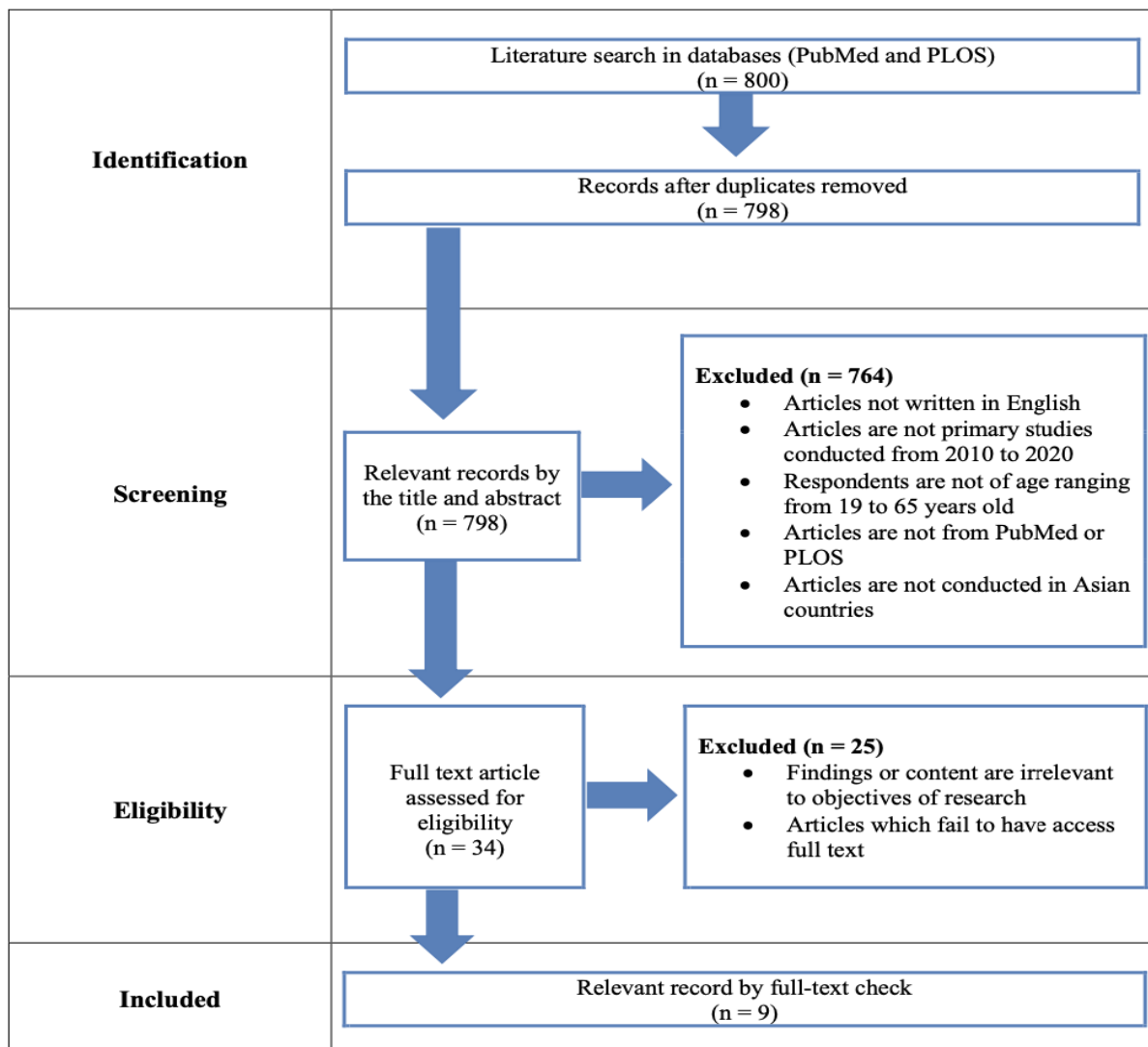
Chua, et al, (2020) stated that 3-ply surgical masks are commonly used during COVID-19. The 3-ply surgical mask is made up of three different layers of nonwoven fabric where each layer of the face mask has its own specific function to combat the COVID-19 pandemic. A study done by Samannan et al., (2020) showed that among 15 healthy people, all of them experienced an increase in respiratory rate from the mean ( $\pm$ SD) of 0.52 ( $\pm$ 0.5) to 1.13 ( $\pm$ 1.4) after 30 minutes of wearing surgical face masks. Another study comparing the facial skin temperature and the heat flow suggests that N95 respirators are able to induce an increased facial skin temperature, greater discomfort, and lower wearing adherence when compared to the surgical masks ( $p < 0.05$ ) (Scarano, et al, 2020).

The focus on constituents of Asia has been compared following its ability to tackle the issues on the control of pandemic during the COVID-19 outbreak. Taking into consideration the socioeconomic status (SES), availability, and limitations of Asian countries that are of good growth, it was brought to attention to view the problems faced by the population related to face mask usage. Therefore, this study aims to identify the prevalence and factors of breathlessness due to the usage of face masks among adults in Asian countries.

## Methodology

This systematic review was conducted based on two databases which were PubMed and PLOS, from the year 2010 to 2020 and focused on the prevalence and factors of breathlessness due to the usage of face masks among adults in Asian countries. Preferred Reporting Items for a Systematic Review and Meta-analysis (PRISMA) checklist was used as a guide for the search strategy.

The inclusion criteria for the articles include articles must be written in English, published as a primary study from 2010 to 2020, must be conducted in Asian countries, studies must be conducted among 19 to 65 years old, and articles from PubMed and PLOS. The articles which failed to fulfil the research objectives and were unable to access the full text were excluded. The phases in the selection of papers were shown in Figure 1.



**Fig 1:** PRISMA flow diagram

Data extraction has been done by two researchers for cross-checking and if there were any disagreements during the process, a third researcher's opinion will be used to reach a consensus. A total of 798 articles were retrieved from PubMed and PLOS, following the removal of two duplicated articles. Based on the total, 764 articles were excluded upon screening based on the title, abstract and

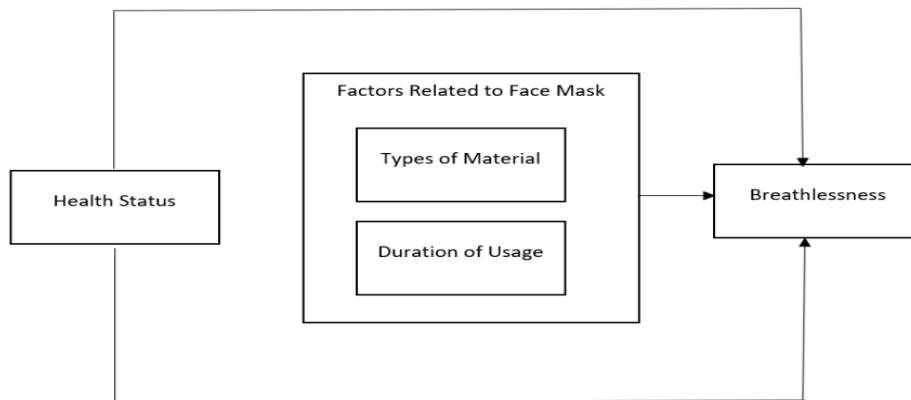
exclusion criteria. The remaining 34 full-text articles were then reviewed to assess their eligibility, and an additional 24 articles were then excluded based on the inclusion criteria.

Articles have been assessed and guided by Newcastle Ottawa Scale (NOS), studies were scored based on three categories, namely selection study group (four criteria), comparability of study groups (one criterion), and outcome (three criteria). The score was given ranged from 0 (lowest quality) to 9 stars (highest quality). The studies chosen have been categorised as high (7-9), medium (4-6) and low (1-3) based on the cumulative marks received through the NOS form.

Once obtaining the data, the articles were tabulated in Table 1, which comprises several categorizations: title, objective(s) of studies, study design, place of study, age group, prevalence and factors causing breathlessness.

## Results

Our studies highlighted three main factors leading to breathlessness in relation to face mask usage which are types of material and duration of usage. This can be depicted by the conceptual framework (Figure 2.0.)



**Fig 2:** Conceptual Framework on Factors Affecting Breathlessness upon Wearing Face Masks

### 3.1 Prevalence

Our findings reveal that five out of nine articles analysed the prevalence of breathlessness upon wearing face masks, whereby three articles contributed to the prevalence of breathlessness upon wearing face masks. The average prevalence of breathlessness is 19 % to 100%. However, the remainder suggested that the face mask usage is protective and does not lead to detrimental health effects.

### 3.2 Types of Material

Out of nine articles, only three discussed the types of material, highlighting the N95 masks, which may lead to breathlessness in comparison with surgical and medical masks.

The studies have shown that N95 has a more protective mechanism but has a higher count of breathlessness upon the usage as compared to the medical mask (Macintyre et al, 2014), in which it perceived more disturbance, a higher score of heat tightness and increased the perception (Fikenzer et al, 2020). However, the surgical mask was less effective in air leakage prevention after coughing (Hui DS et al, 2012).

### 3.3 Duration of Usage

Prolonged usage of face masks and their association with breathlessness were discussed in two out of nine included articles.

A study by Roberge et al. (2012), shows an increase in respiratory rate associated with surgical masks compared to control. The mean respiratory rate over 1 hour was 23.3 breaths-per-minute in the current study, reflecting an increase of 1.6 breaths-per-minute over controls.

Macintyre et al. (2016) mentioned that wearing masks by surgeons and other operation theatre staff was to protect patients from contamination during surgery. On average, participants in the mask arm used a mask for 4.4 hours, while participants in the control arm used a mask for 1.4 hours.

**Table 1:** The Prevalence and Factors Of Breathlessness Caused By Usage Of Face Masks Among Adults In Asian Countries

Title	Objective (s)	Study design	Place of Study	Prevalence of breathlessness	Factors causing breathlessness
Facemask against viral respiratory infections among Hajj pilgrims: A challenging cluster randomised trial	To assess the effectiveness of face masks against viral respiratory infections	Cluster RCT	Saudi Arabia	Among 3,864 of the participants, 26.2 % of the participants were found to have difficulty in breathing and 22% were having discomfort upon wearing a face mask.	-
Effects of surgical and FFP2/N95 face masks on cardiopulmonar	To assess the effect of wearing a surgical and an FFP2/N95 face mask on	Cross-sectional	Asian countries	All 12 volunteers (100%) had an increased respiratory rate and reduced FVC after	Both surgical face mask and filtering facepiece mask significantly reduce the dynamic lung

Title	Objective (s)	Study design	Place of Study	Prevalence of breathlessness	Factors causing breathlessness
y exercise capacity	cardiopulmonary exercise capacity			wearing surgical masks over 1 hour compared to those who wear a filtering facepiece mask.	<p>parameters. The average reduction of FVC was <math>-8.8 \pm 6.0\%</math> with surgical mask and <math>-12.6 \pm 6.5\%</math> with filtering facepiece mask. FEV1 was <math>-7.6 \pm 5.0\%</math> lower with surgical mask and <math>-13.0 \pm 9.0\%</math> with filtering facepiece mask compared to no mask.</p> <p>Wearing of face mask is perceived as the disturbing and increased the perception of exertion</p>
Effects of wearing facemasks on the sensation of exertional dyspnea and exercise capacity in healthy subjects	To test the hypothesis that wearing face masks affects the sensation of dyspnea, pulse rate, and percutaneous arterial oxygen saturation during exercise.	Cross-sectional	Japan	Among all 24 participants who wore a face mask (surgical and cloth), all of them had increased respiratory rate and heart rate after the treadmill test compared to those without a face mask.	-
Exhaled Air Dispersion during Coughing with and without Wearing a Surgical or N95 Mask	To reveal the expelled air during coughing bouts, based on our established laser visualisation technique using smoke as a marker, in a high-fidelity human patient simulator (HPS)	RCT	Hong Kong	-	<p>Types: N95, surgical face mask</p> <p>Usage of N95 mask was more effective than a surgical mask in preventing air leakage forward during coughing.</p>

Title	Objective (s)	Study design	Place of Study	Prevalence of breathlessness	Factors causing breathlessness
A tuberculin skin test survey among healthcare workers in two public tertiary care hospitals in Bangladesh	To determine the prevalence of LTBI and compare the prevalence among different groups	Cross-sectional	Bangladesh	Among 190 of the healthcare workers who were wearing face masks, 40% (75/190) were found to have symptoms of LTBI, including breathlessness.	-
Efficacy of face masks and respirators in preventing upper respiratory tract bacterial colonization and co-infection in hospital healthcare workers	To compare the efficacy of medical masks (MM) and N95 respirators (N95) in preventing bacterial colonization / infection in healthcare workers (HCWs)	Cluster RCT	China	-	N95 respirators were significantly more protective than medical masks against the laboratory - confirmed presence of bacteria, with an efficacy of 46% against medical masks and 62% against control.
Cluster randomised controlled trial to examine medical mask use as source control for people with respiratory illness	To determine whether medical mask use by sick individuals with ILI protects well contacts from related respiratory infections	RCT	China	-	3.9 - 4.9 hours of usage to face masks leads to respiratory symptoms
Impact of Intensive Handwashing Promotion on Secondary Household Influenza-Like Illness in Rural Bangladesh: Findings from a Randomised Controlled Trial.	To find out risk factors for transmission of influenza and influenza-like illness among household contacts of index case-patients in the control arm	Cross-sectional	Bangladesh	Influenzas ranged from 8% to 17% among household contacts, with the 8% secondary attack ratio for influenza detected in a pilot study in Hong Kong of non-pharmaceutical interventions.	-

Title	Objective (s)	Study design	Place of Study	Prevalence of breathlessness	Factors causing breathlessness
Absence of consequential changes in physiological, thermal and subjective responses from wearing a surgical mask	To assess consequential changes in physiological, thermal and subjective responses from wearing a surgical mask.	Cross-sectional	Asian countries	Out of 20 participants, 81% (16/20) had various complaints such as increased facial warmth, mask sticking to face, pinching of the skin and so on, which may lead to breathing difficulties.	Surgical mask use resulted in increases in heart rate (9.5 beats/min; $p < 0.001$ ), respiratory rate (1.6 breaths/min; $p = 0.02$ ), and transcutaneous carbon dioxide (2.17 mmHg; $p = 0.0006$ ), and decreased temperature of uncovered facial skin (0.40 °C; $p = 0.03$ ). The changes could be due to the resistance of filtration media in surgical masks.  The mean RR over 1 h was 23.3 breaths-per-minute in the current study, reflecting an increase of 1.6 breaths-per-minute over control.

## Discussion

The main purpose of this systematic review was to assess the factors of breathlessness in the usage of face masks within the Asian population specifically on the duration of usage and types of masks. This systematic review reveals that the type and duration of face masks usage are the most common factors giving rise to the outcome.

Among the five articles, the range of prevalence of breathlessness was 26% to 100%. Alfelali, et al., (2020) showed that 26.2% of the participants face difficulty in breathing while using facemasks. However, there was no significant difference in the prevalence of breathlessness between the intervention group (participants who wear face masks daily) and the control group (participants who never wear face masks daily). Based on a study by Islam, et al., (2020), 40% were found to have symptoms of latent tuberculosis infection (LTBI) including breathlessness. The difference in the prevalence of breathlessness is not solely reflecting the interventions, rather the difference in sample size across each study has contributed to the end prevalence.

By gender-based subgroup analysis, the prevalence of LTBI was 33.12% (95% CI 18.97% to 49.04%) and 32.65% (95% CI 19.79% to 47%) in males and females, respectively. Roberge., et al., (2012) in their studies revealed that 81% of participants also face breathing difficulty which is in line with another study affecting 12% of children and 38% of adults (Canini et al., 2010). In addition, a marked relationship between the perception of increased breathing resistance for both Surgical Masks and Filtering Face Respirators was reported in a study by Li et al. (2005). However, further studies in controlled settings have to be done to avoid biases such as underreporting or over-reporting responses. For instance, the outcome obtained from children may be influenced by many other factors such as non-compliance, and inconsistency in wearing face masks. Fikenzer., et al., (2020) showed increased respiratory rate and reduced FVC among all 12 volunteers after using face masks. Similarly, the prevalence of breathlessness in a study by Fukushi et al., (2020) was also 100%.

MacIntyre., et al., (2016) mentioned that 3.9 - 4.9 hours of usage of face masks leads to respiratory symptoms. On average, healthcare professionals in the mask arm used a mask for 4.4 hours, while in the control arm used a mask for 1.4 hours. The average time for healthcare professionals in PPE takes up about 6.8 hours (Aloweni, et al., 2022) which leads to an increase in respiratory symptoms during usage. In addition to this, Morris, et al., (2020) also stated that prolonged usage of face masks gives rise to heat and humidity which affects breathing and leads to dyspnea by 25% as it aggravates heat stress, particularly among healthcare professionals who wear additional PPE along with face masks.

Roberge et al., (2012) also showed an increase in respiratory rate upon usage of surgical masks compared to control. This could be a result of carbon dioxide (CO<sub>2</sub>) retention as mentioned by Rhee, et al., (2021) who stated that overall, the mean CO<sub>2</sub> was 0.27% when not wearing a facemask, and the CO<sub>2</sub> concentration increases by 10 times with KN95 respirator. In conclusion, dyspnea is aggravated with prolonged facemask usage ( $p = 0.04$ ), resulting in 36% greater breathlessness.

We also found that types of materials of facemasks are one of the factors causing breathlessness upon wearing facemasks. Among the three articles discussing the types of material of facemasks causing breathlessness, all of them showed that N95 face masks cause more breathlessness than other types of facemasks (Eg. surgical masks, medical masks). A study was done by Fikenzer., et al., (2020) on the effects of surgical and FFP2/N95 face masks on cardiopulmonary exercise capacity showing that Filtering facepiece mask / N95 significantly reduces the dynamic lung parameters more than surgical masks with the average reduction of FVC was  $-8.8 \pm 6.0\%$  with a surgical mask and  $-12.6 \pm 6.5\%$  with filtering facepiece mask. FEV1 was  $-7.6 \pm 5.0\%$  lower with a surgical mask and  $-13.0 \pm 9.0\%$  with a filtering facepiece mask compared to no mask. The peak flow measurement showed that both the surgical mask and filtering facepiece mask significantly reduced the PEF ( $-9.7 \pm 11.2\%$  and  $-21.3 \pm 12.4\%$ , respectively). All the results from this study showed that N95 masks reduce various respiratory parameters more than surgical masks. This might be because N95 face masks are more tight-fitting compared to surgical masks which are loose-fitting. Karuppasamy et al., (2021) reported that a sealed face mask leads to a marked

reduction in an inward leakage of aerosols, consequently giving rise to breathlessness.

Hui, et al., (2012) showed that there was a more significant reduction in average air dispersion distance with N95 mask compared to surgical mask ( $15.1 \pm 2.7$  cm,  $30.0 \pm 3.4$  cm respectively) in which reduction in air dispersion increases breathing resistance (Ng et al., 2020; Lee & Wang, 2011). In addition, an increase in upper airway obstruction induced by added resistance at the mouth reports similar effects on the lung functions parameter with increased breathing resistance (Melissant et al., 1998), whereby the reduction in ventilation resulted from a lower breathing frequency, corresponding to changes of the inhaling and exhaling time and reduced tidal volume. This is seen with the effects of respiratory protective devices or additional external breathing resistance (Louhevaara et al., 1984).

### **Conclusion**

This study concludes that the prevalence of breathlessness is high upon face mask usage with types and duration as contributing factors leading to breathlessness.

Our studies have come across limitations whereby the face mask usage is deemed as fairly new to the current global population as its daily wear, thus a minimal amount of studies was found.

We suggest further research be done with regard to the face masks specifically on their psychological impact, the perception of face mask usage on a daily basis, and how the users perceive its well-being. We hope in light of our studies that the production of face masks would be improvised and well suited to the current generation.

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