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Prolonged Face Mask Use During COVID-19 Pandemic Contributes to Increased Symptoms and Signs of Dry Eye: A Systematic Literature Review

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A B S T R A C T

Introduction: Face mask has been a vital protective equipment against COVID-19 in this pandemic era. Several ophthalmic complaints have been associated with face mask use, leading to the term "mask-associated dry eye". There's still a question that arises whether the duration of use contributes to the condition. This review aimed to assess the correlation between prolonged face mask use on dry eyes. **Methods:** A thorough systematic search was performed through PubMed, Science Direct, and Google Scholar, following the PRISMA 2020 Guideline. Keywords were "mask associated dry eye," OR "dry eye AND face mask" OR "OSDI" OR "tear break up time" AND "COVID-19 pandemic". **Results:** A total of 1130 articles were identified, and only six cross-sectional studies met the eligibility criteria. Prolonged face mask use is correlated with decreased TBUT in four studies, decreased Schirmer score in two studies, and lower TM parameter in one study. Increased duration of wearing mask is correlated with more frequent symptoms and severity of dry eye according to either OSDI, SPEED Questionnaire or another unspecified questionnaire found in five studies. **Conclusion:** Prolonged face mask use during the COVID-19 pandemic contributes to increased symptoms and signs of dry eye.

1. Introduction

The face mask has been a vital protective equipment against COVID-19 in this pandemic era. As it is proven to be effective, World Health Organization (WHO) recommends continuing the implementation of wearing face masks along with other preventive measures to reduce the transmission of COVID-19.[1] Several ophthalmic complaints have been associated with face mask use, including dry eye. A commentary article has suggested the effect of face mask use on increased cases of ocular irritation and dryness.[2] Many survey studies followed as the topic of mask-associated dry eye (MADE) arose. These studies showed there is an increase in ocular discomfort as well as an increased of subjective symptoms of dry eye related to face mask use.[3–5]

Dry eye is defined as "a multifactorial disease of the ocular surface characterized by a loss of homeostasis of the tear film, and accompanied by ocular symptoms, in which tear film instability and hyperosmolarity, ocular surface inflammation and damage, and neurosensory abnormalities play etiological roles" by The Tear Film & Ocular Surface Society Dry Eye Workshop II (TFOS DEWS II).[6] mask associated dry eye is considered to be classified into evaporated dry eye based on its pathophysiology. As the definition of MADE has not been clearly defined, the recent studies regarding the effect of mask-wearing and dry eye searched for either newly found symptoms of dry eye with face mask use and/or the effect of face mask use on existing dry eye severity. Despite assessing subjective symptoms of dry eye, several studies also

used objective measures to assess signs of dry eye related to face mask use in their studies.[7–11]

The duration of mask-wearing continued to be one of the interesting factors to look for regarding the incidence of mask-associated dry eye. A survey study found that there is no significant association between mask-wearing and symptomatic dry eye disease. The low commitment to mask-wearing is stated to be the reason for the result, despite the self-reported response of mask-wearing hours.[12] Yet some studies found a significant correlation between the prolonged hour of mask-wearing to the symptoms of dry eye.[3,4,13] This review aimed to assess the correlation between prolonged face mask use on dry eyes.

2. Methods

Inclusion and exclusion criteria

In this review, we included English language studies that analysed the association between prolonged face mask use to the increase of dry eye signs and symptom parameters. Prolonged face mask use in this review was described as at least two hours of mask-wearing. The face mask was described as either a regular ordinary (non-medical) mask or a regular protective mask as a surgical mask or respirator. Studies reporting on the association of face mask use with various clinical evaluations of dry eye, including objective and subjective measures, were included. This review excluded studies on a patient with previous dry eye history. Studies that included contact lens wearers, patients with a previous history of other ocular diseases and surgery, and the use of topical medication for the eye were also excluded. Review articles and case reports were excluded. Cross-sectional studies, observational studies, and cohort studies were included.

Search strategy

A thorough systematic search was performed through PubMed, Science Direct, and Google Scholar. These searches included keywords for "mask associated dry eye" OR "dry eye AND face mask" OR "OSDI" OR "tear break up time" AND "COVID-19 pandemic". The search strategy was modified to complement the specific database. The final search was conducted on May 14th, 2022. No limitations were placed on the study location. In this research, we adhered to the preferred items for systematic reviews and meta-analyses (PRISMA) 2020 guidelines.

Screening

Duplicate articles were removed before screening using the Zotero platform. The screening was performed by two independent reviewers. Level 1 screening included the title and abstract screening. Non-English pieces of literature were excluded in this phase. Full-text articles of potentially eligible studies were retrieved. The inclusion and exclusion criteria expressed above were applied to the full-text articles retrieved for level 2 screening. All discrepancies between reviewers were resolved to determine the final set of eligible studies.

Quality assessment

The Joanna Briggs Institute Critical Appraisal Checklist for analytical cross-sectional studies[14] was used to critically appraise and assess the quality of the studies with full-text articles available by two authors independently. This checklist consists of eight assessment criteria with four answer options which are yes, no, unclear, and not applicable. Overall appraisal then decided to include, exclude studies or seek other information.

Data synthesis

The result found will be analysed in a narrative format, with descriptions and explanations to aid comprehension and provide a more obvious conclusion to the reader.

3. Results

Study selection results

The process of study selection is presented in the PRISMA diagram in Figure 1. The search of all databases yielded 1130 results, with 33 from PubMed, 519 from Science Direct, and 578 from Google Scholar.

After duplicates were removed, 1056 studies remained. Twenty studies remained, and 1036 studies were excluded through level 1 title and abstract screening. 916 did not relevant to the study topic, 55 were non-English articles, 53 were review articles, and 12 were a letter to the editor. We excluded additional four articles those full text couldn't be accessed and ten articles through level 2 full-text screening, for reasons shown in Figure 1. In total, six[7–11,15] studies were included in this review.

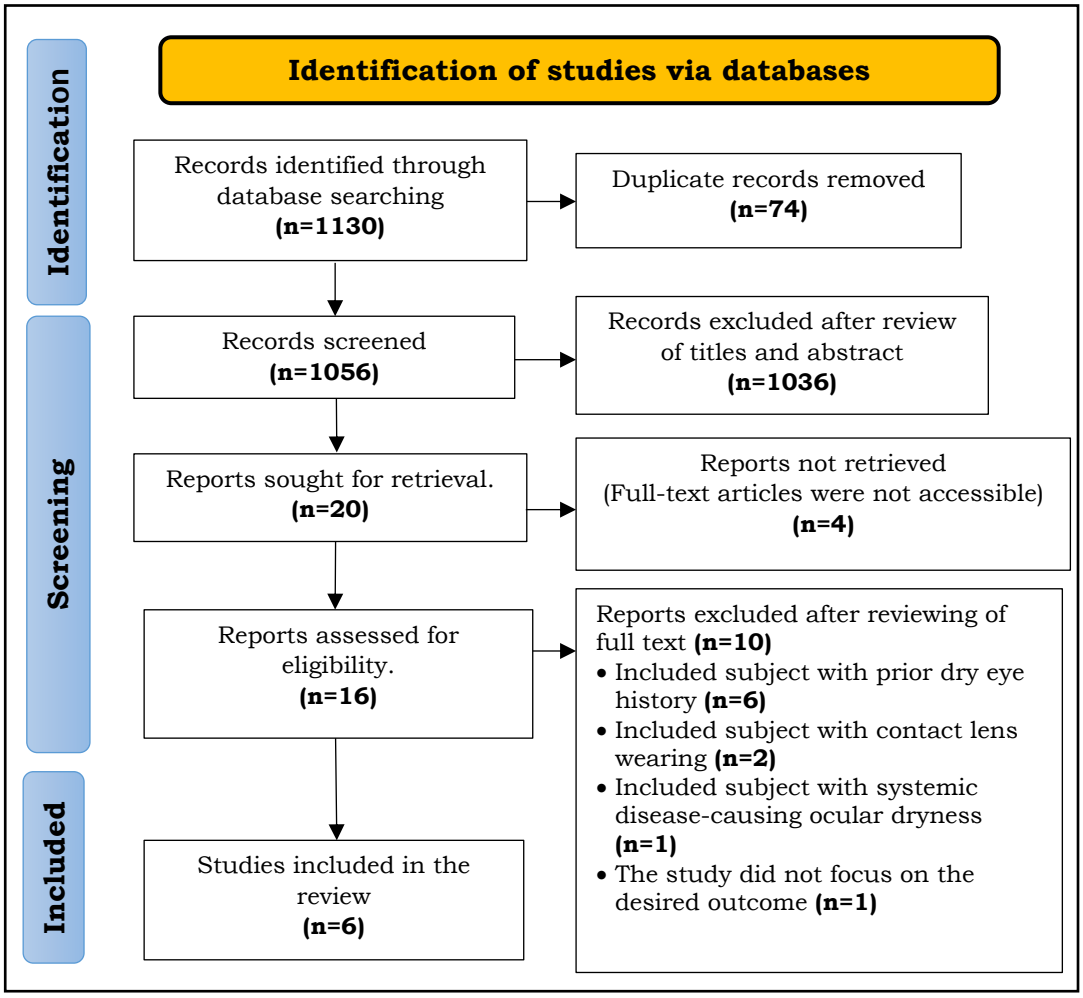

Figure 1. Flow diagram of the systematic review according to PRISMA 2020 guidelines.

Quality assessment results

The Joanna Briggs Institute Critical Appraisal Checklist for Analytical Cross-sectional Studies[14] was used since all six of the included studies were cross-sectional studies. The overall appraisal concluded to include all of the six studies in the review.

Study characteristic

The characteristics of the included studies are presented in Table 1. All studies were published between 2020 and 2022. Five studies were conducted in Asia[7,9–11,15] and one study in Europe[8]. All of the studies were cross-sectional. The sample size ranged from 33 to 169 participants. The majority of the participants were health care workers[8–11,15], with one study including both health care workers and general populations[8], and one study included patients who attended eye care centers as participants[7]. All of the studies excluded subjects with dry eye history and contact lens users.

Subjective measures only were used to assess dry eye in two studies.[9,15] Three studies used both subjective and objective measures.[7,8,10] The remaining study used only objective measures to assess dry eye[10]. Questionnaires were used as subjective measures to assess the presence of dry eye symptoms in five studies. These questionnaires were OSDI in three studies.[7,9,11] One study used a SPEED questionnaire to assess dry eye severity along with an unspecified questionnaire to assess the frequency of dry eye symptoms.[15] One study used a short unspecified questionnaire to assess ophthalmic complaints during mask-wearing and regimen of mask-wearing.[8] Objective measures to assess dry eye were used in four studies, including TBUT measurement,[7,8,10,11] Schirmer test,[7,8,10] tear meniscus height (TMH) and depth (TMD),[10] corneal and conjunctival fluorescence staining,[8,10] BCVA,[8,11] IOP, and anterior segment and fundus examination.[11] The duration of face mask use ranged from two hours to 15.63 hours.[7–11,15]

One study by Marinova et al.[8] regarding ophthalmic complaints in face mask use found several symptoms, such as eye discomfort, redness, tearing, burning sensation, dry eye feeling, foreign body sensation, itching, and blurred vision in 70% of the participants. The subjects were divided into two groups of regular and occasional mask users, with the regular user group having two subgroups with regular protective mask users and regular ordinary mask users. Significantly more often, symptoms were found in regular users than in occasional users ($p<0.001$). Positive correlation between the time of mask usage and the presence and severity of the complaints (Spearman's correlation coefficient $\rho = 0.431$ $p< 0.001$). A positive correlation between frequencies of symptoms for dryness with a duration of wearing a mask was also reported in a study by Gupta et al. This study also stated that there would be an increase (17.1%) in the severity of symptoms with per hour increase in the duration of wearing a mask.[15] Anwar et al. comparing four groups of subjects with different mask-wearing duration, found a positive correlation of OSDI with the duration of mask use. OSDI scores were significantly higher in a group with a longer duration of face mask use ($p<0.001$).[7]

Another study that used OSDI as a parameter by Bista et al. reported that the mean duration of mask-wearing in healthcare workers was 11.30±4.33, with a mean OSDI score was 16.89±19.37. Mean OSDI was statistically correlated with the duration of mask-wearing ($p<0.01$).[9]

Esen Baris et al. conducted a study that compared OSDI scores before wearing and after removing masks among healthcare workers during work hours and found that the mean OSDI score before wearing a mask was 20.1±8.3 (0-68.75) and significantly increased mean OSDI score after removing the mask to 27.4 ±10.4 (0-81.25) ($p<0.01$).[11] TBUT and Schirmer-1 were found to be significantly shorter in groups with a longer duration of face mask use ($p<0.001$), with a negative correlation of TBUT and Schirmer-1 with a duration of wearing face mask stated in a study by Anwar et al.[7] Mean TBUT found significantly reduced from 20.1±8.3 in subjects before wearing a mask to 27.4 ±10.4 ($p = 0.01$) in the subject after removing mask reported by Esen Baris et al.[11]

Bostanci et al. performed a study to assess dry eye in subjects with at least three hours duration of using a mask and found that mean TMH, TMD, and TBUT were significantly lower with a mask on compared to mask off ($p<0.001$) meanwhile, Schirmer score did not significantly change between measurement ($p=0.471$).[10]

Table 1. Studies included in the systematic review.

Author Year Country	Subject	Study design	Duration of mask use	Measurement	Results
Marinova et al., 2020 Bulgaria[8]	144 (Health care workers and general population)	Cross-sectional	Regular mask users (≥ 6 hours/day); Regular protective mask users (RPMU); Regular ordinary mask users (ROMU); Occasional mask user	• Questionnaire • BCVA • Schirmer test • TBUT • CFS	Median age 43 years old (22-79); 70.1% (n=101) reported ocular symptoms; RPMU complained significantly more often symptoms than occasional users (p<0.01); The prevalence of symptoms difference between RPMU and ROMU was not always significant; No significant difference between ROMU and occasional users for most of the symptoms; Significantly more often symptoms in regular users (RPMU+ROMU) than occasional users; Positive correlation between the time of mask usage and the presence and severity of the complaints (Spearman's Correlation Coefficient ρ = 0.431 p< 0.001)
Bista et al., 2021 Nepal[9]	169 (Health care worker)	Cross-sectional	The duration of usage of mask, glasses, and electronic devices were asked with a questionnaire.	OSDI	• Mean age 31.74±7.34 years old (19-59); Average time wearing glasses 7.91±3.81 hours; Average time wearing mask 11.30±4.33 hours; Average duration of VDT 9.90±1.16 hours; Mean sleep duration 7.13±1.16 hours. • According to the OSDI score, 15,9% had mild DED, 8.87% had moderate DED, and 26.03% had severe DED; the Mean OSDI score was 16.89±19.37; Mean OSDI was statistically correlated with duration of mask wear and usage of VDT (p<0.01); Mean OSDI was not statistically correlated with age, glass wear, and sleep duration.
Gupta et al., 2021 India[15]	39 (Health care worker)	Cross-sectional	Wear the mask for ≥ 2 hours	• Questionnaire to assess the frequency • SPEED severity questionnaire	• Mean age 24.69±3.56 years old; Worn cloth mask 38.5%, N95 with valve 15.4%, N95 without valve 30.8%, and surgical mask 15.8%; Dryness was not associated with gender (OR 1.04; CI 95%;0.474-1.26) • Positive correlation between frequencies of symptoms for dryness with a duration of using a mask; No significant relationship between severity of dry eye symptoms with a duration of wearing a mask (r=0.171; p=0.297); There would be an increase (17.1%) in the severity of symptoms with per hour increase in the duration of wearing a mask; the Statistically significant relationship between severity of symptoms and frequency of symptoms (r= 0.638; p=0.000)
Anwar et al., 2021 Bangladesh[7]	100 (Patients who attended eye care centers)	Cross-Sectional	1. Wear mask 2 hours/ day for ≥ 5 days/ week 2. Wear mask 4 hours/ day for ≥ 5 days/ week 3. Wear mask 6 hours/ day for ≥ 5 days/ week 4. Wear mask ≥ 8 hours/ day for ≥ 5 days/ week	• TBUT • Schirmer-1 • OSDI	• Mean age 45±14.9 years old • No significant difference among demographic and baseline characteristics of the groups except the male-female ratio (p=0.02) • Statistically significant differences among the groups' tear film stability assessed by TBUT, Schirmer-1, OSDI • TBUT was significantly shorter in groups with of longer duration of face mask use (p<0.001) • Schirmer-1 measurement significantly reduced with increasing hours of face mask use (p=0.01) • OSDI scores were significantly higher in a group with a longer duration of face mask use (p<0.001) • Positive correlation of OSDI and negative correlation of TBUT and Schirmer 1 with a duration of wearing a face mask
Esen Baris et al., 2022 Turkey[11]	33 (Health care worker)	Cross-sectional	Wear a face mask during work (from 8 am to 5 pm)	• BCVA • IOP • Anterior segment and fundus examination • TBUT (performed twice with a mask on i.e.; at 8 am and 5 pm) • OSDI (filled twice, i.e.; before wearing a mask in the morning; after removing the mask at the end of the workday)	• Mean age 33.6±7.55 years old • The mean total duration that the subject kept the mask on was 514 ± 12.5 minutes (495-526) • Mean BCVA 0.8±0.16 (0.7-1) • Mean IOP 14.6±4.8 (11-19) mmHg • Normal fundus examination in all subjects • Mean TBUT 9.3±1.0 (3-16) seconds at 8 am • significantly reduced mean TBUT to 8.3±1.5 (3-14) seconds at 5 pm (p = 0.01) • mean OSDI score before wearing a mask was 20.1±8.3 (0-68.75) • significantly increased the mean OSDI score after removing the mask to 27.4 ±10.4 (0-81.25) (p<0.01) • no significant difference in worsening OSDI and TBUT scores between gender (p>0.05)
Bostanci et al., 2022 Turkey[10]	86 (Health care worker)	Cross-sectional	Wear surgical mask≥ 3 hours/day	• Corneal and conjunctival staining • Anterior segment optic coherence tomography (AS-OCT) imaging to assess TMH and TMD, TBUT, and Schirmer test performed twice, i.e., while using a mask and 1 hour after taking off the mask	• Mean age 34.4±9.6 years old (18-58) • Male 46.5%; female 53.5% • No mean age difference between genders (p=0.309) • Corneal and conjunctival staining were absent in the subject • Mean TMH and TMD were significantly lower with a mask on (p<0.001) • Mean TBUT was significantly lower with a mask on(p<0.001) • The Mean Schirmer score did not significantly change between measurements (p=0.471) • No difference in mean TMH, TMD, TBUT, and Schirmer test between genders in either mask on nor mask off.

4. Discussion

This systematic review provides some studies that indicate the prolonged use of face masks may be correlated with dry eye disease symptoms and signs. This study was a systematic review of cross-sectional studies. In our study, dry eye disease was assessed by the signs and symptoms of dry eye, which was detected for the first time in the subject when the studies were conducted, without a history of dry eye at baseline. However, there are some studies that only depend on self-reported questionnaires as a tool to assess dry eye and do not assess dry eye with an objective examination.

Face mask-wearing has been a very important measure to control the pandemic situation caused by COVID-19. Despite the declining number of cases from January to June 2022[16], face mask-wearing is still part of the comprehensive strategy to suppress the transmission of COVID-19 and save lives. The effectiveness of face masks against COVID-19 has been stated in a review by Howard et al., which later recommended the widespread use of face masks in public.[17]

Despite its effectiveness, some side effects of face masks used have been proposed, especially in ophthalmology practice. One of them is face mask-associated dry eye (MADE).[2] The prolonged use of face masks for several hours on a regular basis has been predicted to be one of the risk factors for these complaints to happen. The mechanism of face mask use causing dry eye symptoms was proposed as a result of increased evaporation, causing tear hyperosmolarity in the tear film because of the outflow of exhaled air while wearing a face mask.[6,8] Similar mechanism of increased evaporation of the tear film is reported in a study regarding the effect of CPAP.[18] This mechanism can also explain the result of several studies that found a decrease in TBUT and TM parameters associated with mask use, especially with a poorly fitted mask.[7,10,11]

Furthermore, the exhaled air has more carbon dioxide concentration which decreases the pH level of the corneal stroma, stimulates the nociceptor of the cornea, and causes an increase in dry eye symptoms. This mechanism can be the underlying factor that causes the increase in symptoms assessed by OSDI and self-reported questionnaires found in several studies in this review.[7–9,15] The carbon dioxide from exhaled air also causes ocular hypoxia, which leads to ocular inflammation and mucin loss.[7,8]

This systematic review found that several studies found a positive correlation between the duration of mask-wearing and symptoms and signs of dry eye.[7–9,15] The increased duration of face mask use caused the higher temperature of air blowing out from the border of the mask to the surface of the eye in a continuous duration. Warmed air flow can cause an increase in ocular surface sensation, as reported in the DEWS II pain and sensation report.[19] This may be the reason that explains the finding of the studies included.[8–11,15,20]

The type of mask used associated with dry eye disease symptoms and signs was not evaluated in this review. However, most of the studies stated that the type of mask used was a surgical mask, as most of the studies were performed by healthcare professionals.[8–11] Despite the use of surgical masks were not considered a risk factor for dry eye, the increased duration of wearing a surgical mask stated to have a correlation with the presence of dry eye symptoms and signs.[8–11,15] One study stated that the use of cloth masks associated with warming and sweating of that could be one of the contributors that increase symptoms in prolonged use.[15] The use of an N95 mask was stated to have a rarer ocular complaint in the study by Marinova et al. as the tight contact prevents leakage of air through the mask border. However, this situation can lead to mechanical pull of the lower lid resulting in ectropion-like condition and lagophthalmos that causes incomplete blinking leading to dry eye.[8,21]

Dry eye has been stated to have an impact on reduced health-related quality of life (HR-QoL).[21] Therefore, the effect of prolonged mask-wearing on the presence of dry eye during this COVID-19 pandemic should be a concern in ophthalmology practice.

Certain limitations of this study that should be acknowledged, including lack of heterogenicity of the subject related to the prolonged wearing of face masks, were mostly assessed in health care professionals and not various types of occupations and conditions. Several of the included studies only use subjective self-reported questionnaires to assess dry eye without further objective, standardized ophthalmological examination. Finally, our review did not specify the type of mask used that has a correlation with dry eye disease symptoms.

5. Conclusion

There is a significant correlation between prolonged face mask use with increased dry eye disease symptoms and signs. With the mandatory use of face masks in this COVID-19 pandemic situation, more awareness should be raised on the effect of face masks on ocular surfaces, as dry eye is related to impaired health-related quality of life.

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