Study of Face Mask-associated Dry Eye among Medical Students

Abstract

Purpose: The purpose of this study was to evaluate face mask-associated factors causing dry eye among medical students. **Methodology:** This was a cross-sectional study conducted on undergraduate medical and dental students, of all phases, while they were attending offline classes and were required to wear face masks in accordance with the government regulations. Sociodemographic data, ocular and medical history, face mask-wearing practices, screen usage, and quantification of symptoms using the modified Ocular Surface Disease Index (OSDI) questionnaire were collected. Objective tests were conducted in students having dry eye. The association of quantitative variables was done using ANOVA, Mann–Whitney, and Kruskal–Wallis test, whereas the Chi-square test was done for qualitative variables. Multivariate logistic regression was used to identify the risk factors for varying severity of dry eye. **Results:** The mean age of the 410 students was 21 ± 1.6 years. According to the OSDI, 39.51% (162/410) of students had dry eyes, 23.41% (96/410) had mild dry eye, 8.78% (36/410) had moderate dry eye, and 7.32% (30/410) had severe dry eye. Face mask-associated factors which were significantly linked to dry eye were N95 masks, loose-fit masks, and 6–8 h of continuous mask use. The Schirmer's test and tear film break-up time were performed on 29 and 20 students, respectively, mean values being 19.25 ± 5.29 mm and 10.15 ± 1.41 s for nonsevere and 6.53 ± 1.55 mm and 5.3 ± 0.98 s for severe dry eye, respectively. **Conclusion:** It is important to educate medical students and create awareness regarding "face mask-appropriate behavior" to reduce the chances of dry eye secondary to face masks use.

Keywords: *Dry eye, face mask, medical students*

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Introduction

In December 2019, a global pandemic was declared, caused by highly contagious SARS-CoV-2.[1] The use of face masks was recommended to contain its spread.[2,3] Teaching changed from offline mode to online during COVID-19, and then again offline, with compulsory face masks. This made students the ones with maximum daily face mask usage, coupled with prolonged visual display terminal (VDT) exposure.

Various face masks have been used – fabric masks, 3-ply surgical face masks, and N-95 masks, with or without valve – which was largely choice based. There were enough advisories on the constant use of masks but none regarding the correct use of face mask.

In our study, we are assessing the pattern of mask usage among medical students and its impact on their ocular surface, leading to dry eye. Dry eye associated with face masks can be due to tear film instability, excessive evaporation, and inflammation. Identification of various risk factors can help to devise the "face mask-appropriate behavior" which shall ensure better wearability and less ocular side effects, such as dry eye and fogging of glasses. Dry eye, which causes ocular symptoms such as foreign-body sensation, grittiness, redness, and discharge, if present, leads to the deterioration of quality of life and poor-work performance.

Methodology

A cross-sectional study was conducted at a tertiary care teaching hospital from April 01, 2022, over a period of 2 months, when the offline mode of teaching was reinstated. The study population consisted of undergraduate medical and dental students from all professional years. The students who consented and had been attending regular offline lectures for more than 15 days, at a stretch, and were wearing face masks regularly were enrolled. Students with any history of preexisting dry eye,

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ocular surgery, ocular trauma, active ocular medication, using any topical medication, or contact lens (frequency more than once a week) were excluded from the study.

The online questionnaire was created using Google Forms, and the invitation to participate in the study was distributed online among the 1100 students.

Questionnaire

The questionnaire consisted of 26 questions distributed over seven sections:

1. Consent
2. Demographic details: age and gender
3. Relevant ocular and systemic history
4. Face mask related – (a) type of face mask (fabric/3-ply surgical/N-95 with valve/N-95 without valve); (b) fitting of face mask (snug fit/loose fit). Snug fit was categorized as the one which rests adequately on the nasal bridge with nose clips and covers the anterior jawline inferiorly, whereas loose fit was the one worn either below the nose or on the nasal bridge and inadequately secured with nasal clips; and (c) average daily duration of face mask use: categorized as 0–<2/2–<4/4–<6/6–<8/≥8 h
5. Average daily duration of screen exposure: categorized as 0–<3/3–<6/6–<8/≥8 h
6. Average daily exposure to air-conditioned environment: categorized as 0–<3/3–<6/≥6 h
7. Ocular Surface Disease Index (OSDI) questionnaire.[4] In concurrence with studies done earlier, OSDI score of 0–12 was considered normal, 13–22 considered mild dry eye, 23–32 considered moderate dry eye, and ≥33 considered severe dry eye.[5,6]

The above questionnaire was prevalidated by expert ophthalmologists, and a pilot study was run for 30 cases for assessing its reliability and reproducibility, before applying the same over the entire population under the study. The study was conducted according to the Helsinki Declaration principles and was approved by the Institutional Biomedical Research and Ethics committee.

All the students who were found to have dry eye, based on OSDI questionnaire, were counseled to undergo objective tests for dry eye. These tests were conducted in the subjects who consented for the same.

Objective tests

These included Schirmer's test and tear film break-up time (TBUT). The tests were carried out by a single examiner under similar conditions.

A. Schirmer's test: Whatman filter paper no 41 (measuring 5 mm × 35 mm) was placed at the lateral one-third of the lower lid margin in the lower fornix. The extent of wetting of the strip was measured after 5 min. Less than 5.5 mm of wetting was diagnostic of severe dry eye[7]

B. TBUT: The ocular surface was stained with fluorescein. The tear film layer was examined using slit-lamp biomicroscopy and a cobalt blue filter, and the interval from the last blink to the appearance of the first random dry spot on the cornea was noted. The test was repeated thrice, and the mean value was calculated. Value of <10 s was considered tear film instability.[7]

Statistical analysis

The categorical data were presented as number and percentage, whereas the quantitative data were presented as the mean ± standard deviation and as median with 25th and 75th percentiles (interquartile range [IQR]). The data normality was checked using the Kolmogorov–Smirnov test. The cases in which the data were not normal, nonparametric tests were used. The following statistical tests were applied for the results:

1. The association of the variables which were quantitative and not normally distributed were analyzed using the Mann–Whitney test (for two groups) and Kruskal–Wallis test (for more than two groups) and variables which were quantitative and normally distributed were analyzed using the ANOVA
2. The association of qualitative variables was analyzed using the Chi-square test. If any cell had an expected value of <5, then Fisher's exact test was used
3. Multivariate logistic regression was done to find out significant risk factors of dry eye.

The data entry was done in the Microsoft Excel Spreadsheet, and the final analysis was done with the use of Statistical Package for the Social Sciences (SPSS) software (IBM manufacturer, Chicago, IL, USA, version 25.0). For statistical significance, $P < 0.05$ was considered statistically significant.

Results

A total of 546 students responded to the questionnaire, out of which three students did not consent to participate. Thus, 543 students completed the questionnaire representing a response rate of 49.36%. Among those who responded, 50 students were already on treatment for dry eye, 19 students had previously undergone ocular surgery, history of ocular trauma was present in 14 students, and 3 students had active ocular disease during the time when a study was being conducted. Topical medications were already being used by 25 students and 22 gave a history of contact lens use more than once a week. These were excluded from our study. Four hundred and ten students were finally included in the study. The mean age of the students was 21 ± 1.6 years. The majority of the subjects were females (58.05%, $n = 238$), 171 students (41.71%) were males, and 1 (0.24%) was nonspecified.

Regarding the type of face mask used, 50.98% of students ($n = 209$) preferred 3-ply surgical mask; average daily duration of face mask wear ranged between 4 and

8 h in 58.05% (n = 238) students and loose fit mask was worn by 70.73% of students. More than 26% (n = 107) students had 6–8 h of daily exposure to screens. In majority, n = 189 (46.1%) of students, duration of exposure to air-conditioned environment per day was more than 6 h, followed by 3–6 h. Distribution of variables is tabulated in Table 1.

Majority of the students, 60.49%, did not have any dry eye symptoms. However, 162 (39.51%) students were found to have dry eye based on OSDI score. Ninety-six (23.41%) students had mild dry eye, with a mean OSDI score of 16.05 ± 2.89, moderate dry eye was found in 36 (8.78%) students with a mean OSDI score of 26.51 ± 2.57, and severe dry eye was found in 30 (7.32%) students with a mean OSDI score of 41.31 ± 7.72.

All the subjects in whom dry eye was reported were advised to undergo objective tests, Schirmer's test, and TBUT. Twenty-nine and 20 subjects underwent Schirmer's test and TBUT, respectively. For statistical purpose, mean of Schirmer's test and TBUT of a subject was taken by calculating the mean of both eyes, respectively. The mean value of Schirmer's test and TBUT was 13.551 ± 7.577 mm and 7.725 ± 2.755 s, respectively. The association between dry eye based on OSDI score and demographic variables and various associated risk factors was assessed. We found no significant association between demographic variables (age and gender) and dry eye, using the Mann–Whitney test and Fisher's Exact test, respectively.

Table 1: Distribution of variables

Variable	*n* (%)
Type of face mask	
Fabric mask	74 (18.05)
3-Ply surgical	209 (50.98)
N95 without valve	50 (12.20)
N95 with valve	77 (18.78)
Duration of face mask usage per day (h)	
0–<2	60 (14.63)
2–<4	82 (20.00)
4–<6	145 (35.37)
6–<8	93 (22.68)
≥8	30 (7.32)
Face mask fit	
Snug	120 (29.27)
Loose	290 (70.73)
Average daily screen exposure (h)	
0–<3	97 (23.66)
3–<6	160 (39.02)
6–<8	107 (26.10)
≥8	46 (11.12)
Duration of exposure to air-conditioned environment per day (h)	
0–<3	97 (23.66)
3–<6	124 (30.24)
≥6	189 (46.10)

However, the incidence of dry eye was significantly higher in those wearing N95 mask with and without valve, as compared to those wearing fabric (cotton) or 3-ply surgical mask (62%, 77.92% vs. 24.32% and 25.36%, $P < 0.0001$); in those wearing loose fitting mask vis-a-vis snugly fitted one (73.33% vs. 25.52%, $P < 0.0001$); and in those using face mask for average 6–<8 h daily as compared to 0–<2 h, 2–<4 h, 4–<6 h, and ≥8 h (55.91% as compared to 35%, 36.59%, 33.79%, and 33.33%, $P = 0.008$). Distribution of dry eye was, however, comparable with average daily screen exposure and average daily exposure to air-conditioned environment, P values being 0.051 and 0.722, respectively [Table 2].

On performing multivariate logistic regression, type of face mask and face mask fit were significant independent risk factors of dry eye after adjusting for confounding factors. Subjects wearing snugly fitted face mask had significantly low risk of dry eye with adjusted odds ratio of 0.12 (0.068–0.21). Subjects using N95 without valve, N95 with valve had significantly high risk of dry eye with adjusted odds ratio of 4.202 (1.71–10.323) and 11.387 (4.894–26.494), respectively [Table 3].

The association of various variables with the severity of dry eye (severe vs. non severe dry eye) was assessed. Mild and moderate dry eye, according to OSDI score, was clubbed as nonsevere dry eye [Tables 4 and 5].

Severity of dry eye was not affected by age, gender, type of face mask, duration of face mask usage per day, average daily screen time, and average daily duration of exposure to air-conditioned environment. However, compared to tight face mask fit, loose-fitted face mask had significantly higher incidence of nonsevere dry eye (90.91% vs. 70.27%, $P = 0.0008$).

Median (IQR) of OSDI score in nonsevere dry eye disease was 16.7 (14.6–22.9), which was significantly lower as compared to severe dry eye disease (39.6 [33.825–47.9]) ($P < 0.0001$). The mean value of Schirmer's test and TBUT was 19.25 ± 5.29 mm and 10.15 ± 1.41 s in those with nonsevere dry eye and 6.53 ± 1.55 mm and 5.3 ± 0.98 s in those with severe dry eye, respectively.

Discussion

Face masks played a crucial role in combatting the spread of SARS-COVID-19 infection in conjunction with other protective measures such as social distancing and hand hygiene. Although face mask use was mandatory in public areas and confined spaces, it was utmost important for medical students who were exposed to hospital environment.

Face masks, particularly those worn for long periods of time, can cause skin irritation, acne, and difficulty in breathing. It can lead to people touching their face often,

Table 2: Association of various variables with dry eye

Variable	With dry eye (*n*=162), *n* (%)	Without dry eye (*n*=248), *n* (%)	*P*
Type of face mask			
Fabric mask	18 (24.32)	56 (75.67)	<0.0001*
3-ply surgical	53 (25.36)	156 (74.64)	
N95 without valve	31 (62)	19 (38)	
N95 with valve	60 (77.92)	17 (22.07)	
Face mask fit			
Loose	88 (73.33)	32 (26.66)	<0.0001*
Tight	74 (25.52)	216 (74.48)	
Average daily duration of face mask use (h)			
0–<2	21 (35)	39 (65)	0.008*
2–<4	30 (36.59)	52 (63.41)	
4–<6	49 (33.79)	96 (66.21)	
6–<8	52 (55.91)	41 (44.09)	
≥8	10 (33.33)	20 (66.67)	
Average daily duration of screen exposure (h)			
0–<3	34 (35.05)	63 (64.95)	0.05*
3–<6	62 (38.75)	98 (61.25)	
6–<8	53 (49.53)	54 (50.47)	
≥8	13 (28.26)	33 (71.74)	

*Chi-square test

Table 3: Multivariate logistic regression to find out significant risk factors of dry eye

Variable	Beta coefficient	SE	*P*	OR (95% CI)
Type of face mask				
Fabric mask				1.000
3-Ply surgical	−0.056	0.356	0.875	0.945 (0.471–1.899)
N95 without valve	1.436	0.459	0.002	4.202 (1.710–10.323)
N95 with valve	2.432	0.431	<0.0001	11.387 (4.894–26.494)
Duration of face mask usage per day (h)				
0–<2				1.000
2–<4	0.423	0.441	0.337	1.527 (0.643–3.626)
4–<6	0.029	0.394	0.940	1.030 (0.476–2.231)
6–<8	0.812	0.429	0.058	2.254 (0.973–5.221)
≥8	0.140	0.582	0.809	1.151 (0.368–3.598)
Face mask fit				
Loose				1.000
Snug	−2.123	0.288	<0.001	0.120 (0.068–0.210)

SE: Standard error; CI: Confidence interval; OR: Odds ratio

which could increase the risk of infection, if their hands were not clean. Apart from these, wearing a face mask can cause ocular discomfort and fogging of glasses. Given the current scenario, wherein COVID-19 keeps knocking at our door every few months and wearing face masks becomes mandatory, we tried to look for the face mask-related and environment-related factors associated with dry eye among medical students.

In our study, response rate to the questionnaire was 49.36%; however, 410 could be included, as we tried to minimize the student-based confounders. The majority of students, i.e., 50.98%, preferred wearing 3-ply surgical mask. These masks offer good protection against airborne particles and are comfortable to wear, making them a popular choice among students. To our surprise, 70.37% of students wore loose fitting face mask. Such fits, although, make face mask more comfortable and breathable but do not create an effective barrier and offer limited protection. Duration of daily use of face mask ranged between 4 and <8 h in maximum (58.05%) students because wearing face mask was made mandatory in classes and closed environment as per the government guidelines. Daily duration of screen time was high (6–<8 h) among students as VDT comprise an integral and indispensable part of teaching–learning methodology. In our study, 162 students (39.51%) reported symptoms of dry eye, majority of whom had nonsevere dry eye.

We found that, as compared to tight fit face masks, students with loose fit masks had higher incidence of dry eye

Table 4: Association of face mask related variables with severity of dry eye

Parameters	Nonsevere dry eye (n=132), *n* (%)	Severe dry eye (*n*=30), *n* (%)	Total, *n* (%)	*P*
Type of facemask				
Fabric mask	13 (72.22)	5 (27.78)	18 (100)	0.088†
3-Ply surgical	39 (73.58)	14 (26.42)	53 (100)	
N95 without valve	26 (83.87)	5 (16.13)	31 (100)	
N95 with valve	54 (90)	6 (10)	60 (100)	
Duration of face mask usage per day (h)				
0–<2	14 (66.67)	7 (33.33)	21 (100)	0.255†
2–<4	27 (90)	3 (10)	30 (100)	
4–<6	42 (85.71)	7 (14.29)	49 (100)	
6–<8	41 (78.85)	11 (21.15)	52 (100)	
≥8	8 (80)	2 (20)	10 (100)	
Face mask fit				
Loose	80 (90.91)	8 (9.09)	88 (100)	0.0008‡
Snug	52 (70.27)	22 (29.73)	74 (100)	

†Fisher's exact test; ‡Chi-square test

Table 5: Association of environmental factors with severity of dry eye

Parameters	Nonsevere (*n*=132), *n* (%)	Severe (*n*=30), *n* (%)	Total, *n* (%)	*P*
Total screen time per day (h)				
0–<3	23 (67.65)	11 (32.35)	34 (100)	0.053†
3–<6	51 (82.26)	11 (17.74)	62 (100)	
6–<8	48 (90.57)	5 (9.43)	53 (100)	
≥8	10 (76.92)	3 (23.08)	13 (100)	
Duration of exposure to air-conditioned environment per day (h)				
0–<3	29 (82.86)	6 (17.14)	35 (100)	0.727‡
3–<6	43 (84.31)	8 (15.69)	51 (100)	
≥6	60 (78.95)	16 (21.05)	76 (100)	

†Fisher's exact test; ‡Chi-square test

symptoms. Face masks, which are not secured properly around the nose, tend to leave potential space on either side. Breathing within a face mask causes continuous airway positive pressure of exhaled air which is at a temperature higher than the atmospheric air. This hot air passes through the potential space at the upper edge of ill-fitted face mask. In addition, because of the inferior orbital margin's anatomical relation to the anterior surface of the eyeball, heated air directly contributes to the corneal surface's drying. These factors in conjunction cause increased evaporation, hyperosmolarity, instability, and a decrease in tear film renewal, leading to an increase in dry eye symptoms.[8,9]

Certain materials used in face masks can contribute to dry eye symptoms. In our study, we found that N95 mask with or without value increased the risk of dry eye as compared to surgical mask or fabric mask, however, did not affect the severity of dry eye. These findings were consistent with Azzam *et al*.[10] who found that N95 masks were associated with ocular dryness. N95 masks provide an effective shield all around the mouth and nose, leaving hardly any space for the air to escape. However, these masks have a tendency to pull down the lower lid, making the ocular surface more susceptible to dryness. This is probably the reason why, despite minimal air leakage, we found dry eye to be significantly associated with N95 mask. Masks made of synthetic material such as polyester or nylon do not absorb moisture and can trap heat and humidity around the eyes, which can lead to dryness and irritation. In comparison to the rest, cotton masks are considered more breathable as cotton fibers can absorb moisture, allowing air to circulate and reducing humidity around the eyes. It is important here to note that, even the best material for mask will not prevent dry eye if the mask does not fit properly or is worn for a long period of time.

Significantly increased dry eye symptoms were recorded in prolonged face masks usage of 6–<8 h/day in this study. A study done by Giannaccare *et al*.[11] also showed that with average use of face masks more than 6 h/day worsened the ocular surface symptoms. Another study done by Scalinci *et al*.[12] also found that the prolonged use of face masks was associated with increased OSDI score.

Prolonged use of VDT has been identified as a risk factor for dry eye in various studies.[13,14] Several mechanisms such as decreased blink rate, meibomian gland dysfunction, and corneal phototoxicity have emerged as a cause for ocular surface damage and dry eye in VDT use. Along with this, according to another study, blue light emitted from devices contribute in dry eye by increasing reactive oxygen species causing ocular inflammation and suppressing melatonin, a hormone that regulates our sleep–wake cycle.[15] In our study, the distribution of dry eye was comparable with average daily screen exposure and average daily exposure to air-conditioned environment.

Out of 162 students with dry eye based on OSDI score, 29 (17.90%) and 20 (12.34%) students consented to undergo Schirmer's test and TBUT, respectively. This number was proportionately higher as compared to another study,[7] which could be because this study was done on medical students, who being aware of the entity, wish to proceed ahead for their diagnosis and treatment. The mean value of Schirmer's test and TBUT was found to be 19.25 ± 5.29 mm and 10.15 ± 1.41 s in those with nonsevere dry eye and 6.53 ± 1.55 mm and 5.3 ± 0.98 s in those with severe dry eye, respectively.

Our study emphasizes the importance of ocular health awareness and preventive measures. However, there are a few limitations of the current study which must be acknowledged. The findings of the study were based on data collected from single university undergraduate medical and dental students, which may not represent the broader population of medical students. Furthermore, being primarily focused on medical and dental students, the study may not reflect the diversity of the general population. Moreover, in the study, the tests for dry eye were conducted on students who voluntarily consented for the same. These participants are more likely to experience the symptoms, potentially skewing the results. Future studies involving diverse population, larger sample size, and long-term follow-ups are recommended to further evaluate the potential long-term impact of dry eye.

Conclusion

Face mask-related dry eye among medical students was found to be associated with N95 mask, loose-fitted mask, and longer duration of mask use. To improve the wearability of face masks, the authors recommend that the mask should fit properly, with no gaps around the edges, and that it should not sit too close to the eyes. Wearing a mask with flexible nose bridge and adjustable strap may help to reduce pressure on eyes and improve airflow. Taping the upper edge of the mask can also improve ocular surface stability by preventing exhaled air from entering the eye directly. To decrease the likelihood of dry eyes caused by the usage of face masks, it is important to educate and raise awareness about "face mask-appropriate behavior."

Ethical statement

The study was approved by the Institutional Ethical Committee of Biomedical and Health Research, letter number AU/EC/PH/2K21/65 dated 7/12/21.

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Conflicts of interest

There are no conflicts of interest.

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