Original Article

# Prevalence of symptoms of dry eye disease in an urban Indian population

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**Purpose:** The aim of this study was to estimate the prevalence of symptoms of dry eye disease (DED) in an urban population in India. **Methods:** In this cross-sectional study, a two-stage cluster sampling procedure was conducted across 50 municipal wards in the city of Raipur, India, between December 2019 and February 2020, to include 2500 households. Interviewers collected demographic and lifestyle data from participants aged ≥20 years. DED symptoms were assessed using a standard six-item validated questionnaire. The presence of one or more of the six dry eye symptoms often or all the time was considered positive for DED symptoms. **Results:** In this study, 2378 people completed the survey of whom 1397 (58.7%) were males and 981 (41.3%) were females. The crude and overall age-adjusted prevalence for any positive symptom was 6.5% and 6.8% (95% CI: 5.8–7.8%), respectively. The commonest symptom was red eyes (2.8%) followed by burning sensation (1.8%), foreign body sensation (1.7%), dry eyes (1.2%), gummy eyes (1.2%), and crusts on eyelashes (0.8%). The associated risk factors were female sex, use of digital display, smoking and stay in an air-conditioned environment. **Conclusion:** The prevalence of DED symptoms in this urban Indian population was less than the prevalence reported in most other population-based studies from outside India, and lower than other hospital-based studies from India. Hence, DED prevalence in India is either lower than current estimates or is non-uniform in distribution.

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Worldwide, dry eye disease (DED) is emerging as an important cause of ocular morbidity. In different population-based studies, the prevalence of DED ranges from 5 to 50%.[1] This wide variability in prevalence data can be attributed to two factors: differences in demographic characteristics and the choice of DED diagnostic criteria or tests used in the study. Similar to global patterns, the prevalence rate of DED in India also shows wide variation. Recently, a hospital-based study from north India reported a prevalence rate of 32%, in which a majority of the patients were categorized with moderate to severe DED.[2] Another study from south India reported an incidence rate of 1.46%.[3] In contrast to these, there are other studies from India, in which a lower prevalence rate has been reported. Rege *et al*. reported a prevalence rate of 15.4%,[4] while Sahai *et al*. reported a prevalence rate of 18.4%.[5] In a recent study from our center, where 570 subjects were evaluated for DED and meibomian gland dysfunction, we estimated a prevalence rate of 19.0% (95% Confidence Interval [CI] 15.7–22.1%).[6]

The ideal method to estimate the prevalence rate of a disease is through population-based studies, as hospital-based studies are prone to selection bias. Generalization of data from hospital-based studies to the population tends to be inaccurate. Unfortunately, all the studies that have estimated the prevalence of DED in India were hospital-based, and no population-based studies have ever been carried out. As dry eye is a symptomatic disease, evaluation of symptoms is very important and in recent times this has become a significant area of focus amongst clinicians and researchers.[1,7] The recent guidelines of the Dry Eye Workshop conducted in 2017 emphasize the importance of assessment of symptoms in DED and have made it an integral component in its diagnostic criteria.[8] The estimation of only symptom prevalence as a surrogate measure of DED has previously been used in many studies from developing countries.[9-13] As there is no population-based prevalence data of DED or its symptoms in India, we believe that estimating the prevalence of symptoms can also indicate the magnitude of the disease. Therefore, the aim of this study was to estimate the prevalence of DED-related symptoms in an urban Indian population.

## Methods

### Participants

This cross-sectional population-based study was carried out at a tertiary eye care institute in central India between December 2019 and February 2020. The study was approved by the Ethics Committee of the Institute and adhered to the tenets of the Declaration of Helsinki. The study was conducted in Raipur, which is the capital of Chhattisgarh state. The city is located 21°23″ north and 81°65″ east at an elevation of 298.15 m from sea level. It has a tropical dry and wet climate, with an average annual temperature of 20.7°C to 33.2°C and average relative humidity of 49%. The city is industrialized with over 10,000

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industrial units.[14] The urban population of Raipur comprises of 1,010,087 people, of which 519,286 are male and 490,801 female.[15]

### Sampling

A two-stage cluster sampling method was used similar to the "random walk" technique of the World Health Organization Expanded Program for Immunization,[16] as a reliable sampling framework of the study population could not be obtained. The intended study sample size was 2500 persons. In the first stage, 50 wards from a total of 70 wards within Raipur Municipal Corporation were selected using a simple randomization procedure. This was followed by the actual survey, in which the interviewers visited one to two localities within the selected ward, and the first household encountered on entering the locality became the starting point for the survey, till 50 consecutive households were included. From each household, only one member ≥20 years was randomly selected. Individuals with red or painful eyes, gross anatomical anomaly, using any eye drops, or having undergone any eye surgery within the last three months were excluded. A household in which no eligible subjects were available at the time of visit, or that refused consent, or any multi-storied apartment buildings or gated societies were skipped. Verbal consent was obtained from all the participants in the presence of another family member or a neighbor.

### The questionnaire

The interviews were conducted by two authors (GS and RK). Information related to age, sex, level of education and occupation (as per the modified Kuppuswamy scale),[17] smoking history, usage of mobile phones/televisions/video display units and exposure to air-conditioning were recorded on an Internet-based data collection form accessed by a smart phone. The symptoms of DED were measured by a previously validated six-item symptom questionnaire.[18,19] The questionnaire consisted of the following questions: (1) *Do your eyes ever feel dry?* (2) *Do you ever feel a gritty or sandy sensation in your eyes?* (3) *Do your eyes ever have a burning sensation?* (4) *Are your eyes ever red?* (5) *Do you notice much crusting on your lashes?* and (6) *Do your eyes ever get stuck shut?* The responses were graded as *never*, *rarely* (at least once in 3-4 months), *sometimes* (once in 2-4 weeks), *often* (at least once a week) or *all the time*. A symptom was considered *positive* if it was reported *often* or *all the time*.[9,11,18,19] Internal consistency and intra-class reliability were tested on a pilot sample prior to the study. The Cronbach's alpha was 0.65 and the intra-class correlation coefficient between the two interviewers was 0.87 (95%CI: 0.60-0.96).

### Statistical analysis

Quantitative and qualitative variables were expressed as mean ± standard deviation and percentages, respectively. Age-adjusted prevalence with a 95% confidence interval (CI) was calculated by considering the census population data of India in 2011.[20] The correlation between risk factors and symptoms were analyzed by Spearman's rank correlation and association using binary logistic regression. All tests were computed using statistical software SPSS version 23.0 (SPSS, Chicago, IL). A two-tailed *P* value of less than 0.05 was considered statistically significant.

## Results

### Demographic characteristics

The target sample population was 2500 subjects, from which 2378 (95.1%) completed the survey. Sixty-seven subjects declined to participate. Fifty-five subjects were excluded from the study, from which 20 subjects had undergone ocular surgery within the past 3 months, and 35 subjects had painful red eyes or were using eye drops.

The demographic characteristics of the study population are given in Table 1. There were 1397 (58.7%) male and 981 (41.3%) female subjects. The mean age was 44.3 ± 13.7 (median: 43, range: 20-89) years. There were 205 (8.6%) smokers, who smoked 0.3 ± 1.6 (range: 0-30) cigarettes per day. There were 2294 (96.55%) people who reported usage of mobile phone`visions/video display units, and the mean time spent on such devices was 3.8 ± 2.6 (range: 0-18) hours. The number of subjects using air-conditioning was 485 (20.4%) and the mean time spent in such conditions was 1.31 ± 2.9 (range: 0-24) hours.

### Symptoms

The frequency of responses to the six-item questionnaire is given in Fig. 1. The most common symptom was red eyes in 67 (2.8%) subjects, followed by burning sensation in 42 (1.8%), gritty sensation in 41 (1.7%), dry eyes in 28 (1.2%), gummy eyes in 28 (1.2%), and crusts in the eyelashes in 8 (0.8%) subjects. Overall, 155 (6.5%) subjects reported 1 or more of the 6 symptoms in the DED questionnaire to be present *often* or *all the time*. One symptom was reported by 115 (4.8%) persons, 2 were reported by 28 (1.2%) persons, 3 were reported by 9 (0.4%) persons and 4 were reported by 3 (0.1%) persons. None of the subjects experienced more than 4 symptoms.

### Prevalence of symptoms of DED

The age-adjusted prevalence of positive symptoms in different age and sex categories is given in Table 2. The crude and overall

**Table 1: Demographic characteristics of the study sample (*n*=2378)**

| Variable | Number (percent) |
|---|---|
| Sex | |
| Males | 1397 (58.7) |
| Females | 981 (41.3) |
| Age in years | |
| 20-39 | 907 (38.1) |
| Males | 473 (52.1) |
| Females | 434 (47.9) |
| 40-59 | 1037 (43.6) |
| Males | 624 (60.2) |
| Females | 413 (39.8) |
| ≥60 | 434 (18.3) |
| Males | 300 (69.1) |
| Females | 134 (30.9) |
| Education | |
| Illiterate | 152 (6.4) |
| Primary | 120 (5.0) |
| Middle | 201 (8.5) |
| 10th pass | 301 (2.7) |
| 12th pass | 434 (18.3) |
| Graduate/Post-graduate | 1170 (49.2) |
| Occupation | |
| Unemployed | 1119 (47.1) |
| Unskilled worker | 200 (8.4) |
| Semi-skilled worker | 68 (2.9) |
| Skilled worker | 305 (12.8) |
| Clerical/shop-keeper/farmer | 393 (16.5) |
| Semi-profession | 95 (4.0) |
| Profession | 198 (8.3) |

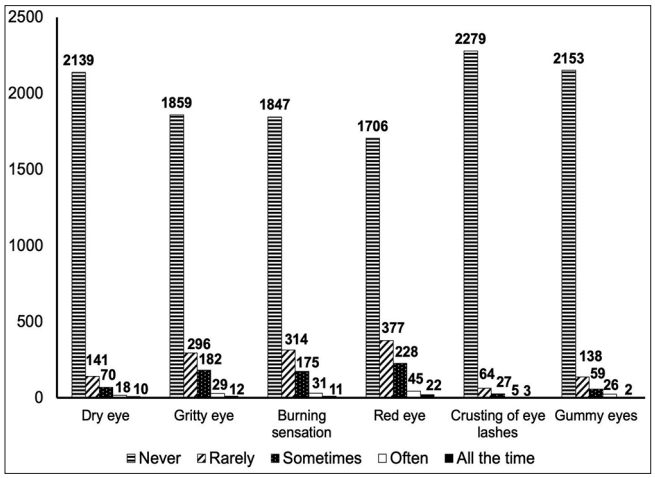


**Figure 1:** Distribution of symptoms by the frequency of responses

age-adjusted prevalence for any positive symptom was 6.5% and 6.8% (95% CI: 5.8–7.8%), respectively. The crude and overall age-adjusted prevalence for any positive symptom in male and female subjects was 6.1% and 6.5% (95%CI: 5.2-10.8%), and 7.0% and 6.9% (95%CI: 5.3–8.4%), respectively.

### Risk factors

The various risk factors are given in Table 3. While DED symptoms were highest in the 20-39 years age group followed by 40-59 years, the adjusted odds ratio for this age group was statistically not significant ($P$ = 0.248). The female subjects displayed an increased risk [odds ratio: 1.51 (95% CI: 1.06-2.16); $P$ = 0.021) on adjusting for other factors. Smoking (Spearman's σ = 0.057, $P$ = 0.005), use of mobile phones/televisions/video display units (Spearman's σ = 0.076, $P$ < 0.0001) and staying in an air-conditioned environment (Spearman's σ = 0.060, $P$ = 0.004) correlated significantly with positive DED symptoms. They were also significantly associated with the risk of DED symptoms in the multiple regression analysis [Table 3]. There was no increased risk with the level of education or occupation type. Hence they were not included in the regression analysis.

## Discussion

This urban population-based study in India estimated the prevalence of DED symptoms to be lower than most other studies that evaluated only symptoms [Table 4]. Our results are parallel to the findings of a study from Singapore, which reported a prevalence of 6.5% using the same six-item questionnaire.[21] Assessing symptoms with the six-item questionnaire, or other shorter questionnaires in DED surveys of the population is not new,[9-13] and accepted because they are easy to use, repeatable and are designed to obtain maximum information with minimal questioning.[1,7] Therefore, our study does not estimate the prevalence of DED, but only the distribution of its symptoms in the population.

In our study, the single most common symptom was redness in eyes, followed by burning sensation and foreign body sensation. Very few patients complained of dry eyes, crusts in eyelids, or gummy eyes. In a majority of the previous studies, symptoms of ocular irritation (burning sensation, grittiness, and redness) were also more commonly reported than actual dry eyes.[9,11,18,21] Lee *et al*. reported burning sensation as the most common symptom, followed by grittiness and redness.[9] Ocular allergy, contact lens usage,[1,7] and environmental air-borne pollutants[22,23] can also cause ocular irritation and tear film dysfunction. As Raipur is an industrialized city with a large number of manufacturing units,[14] the possibility of chronic exposure to particulate and non-particulate pollutants, which can cause tear film dysfunction or ocular irritation[22,23] cannot be ruled out.

We identified female sex, smoking, use of mobile phones/televisions/video display units and staying in an air-conditioned environment as risk factors for DED symptoms. These also correlated significantly with the presence of any one symptom of DED. All of these are known risk factors for DED.[1,24,25] In our study, older females had a higher prevalence rate of symptoms in comparison to males [Table 2], which is related to the hormonal difference between the two genders, and the effect of menopause on tear physiology.[24] Most studies have also reported a similar observation.[3-5,10-13,18,19] In our study, young and middle-aged subjects reported greater number of symptoms than elderly subjects, although this difference was not significant on age-adjustment. In a previous study on meibomian gland dysfunction, we observed fewer symptoms among elderly patients, even though there was a greater amount of lid margin changes in them.[26] Symptom perceptions in elderly subjects may be less due to changes in corneal nerve morphology and reduction in ocular surface sensitivity with increasing age.[27]

While evaluating both symptoms and signs of DED would have made our findings more robust, there are challenges in conducting such a study in the community. Also, previous studies have reported variability in prevalence rates when both symptoms and signs were included in the diagnosis criteria for DED. There was a tendency towards underestimation of prevalence rate with signs, and there was a poor correlation between symptoms and signs.[6,19,28] The random walk method of sampling that we adopted may not be the most ideal technique, as this method does not use a sampling framework, and the selection of the subjects is left to the interviewer. However, this sampling method is advantageous in a developing country where population rolls are often inadequate. If one compares the random walk method with the more ideal compact sampling technique, the differences in point estimates are found to be negligible.[29] Few people reported using eye drops and they were not included in the survey. Some of them may have been using ocular lubricants for DED and were thus inadvertently excluded. The simple six-item questionnaire ensured that we obtained complete responses. Moreover, the questionnaire showed sound internal consistency and low inter-rater variability. Our use of an Internet-based data collection form on a smart phone was inexpensive, paperless, allowed for real-time monitoring of data entry, avoided delays and errors related to transfer of data from paper forms, and instantaneous extraction of results facilitating a quicker analysis.

## Conclusion

We believe that the findings of our population-based study on symptoms offer insights into the magnitude of DED in India particularly in the absence of similar community-based studies. Our more conservative findings of symptom prevalence indicate that the actual magnitude of DED in urban India may either be lower than what has previously been reported in hospital-based studies, or is non-uniformly distributed across the country. A more representative estimate of the magnitude of the disease can be obtained by studies across the country as India is diverse

**Table 2: Prevalence of symptoms**

| | Number (percent) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Any symptom | Dry eye | FB sensation | Burning Sensation | Red eye | Eye lid margin crusts | Gummy eyes |
| Overall | | | | | | | |
| Total *n*=2378 | 155 (6.5) | 28 (1.2) | 41 (1.7) | 42 (1.8) | 67 (2.8) | 8 (0.3) | 28 (1.2) |
| Age-adjusted prevalence | 6.8 (95%CI: 5.8-7.8) | 1.3 (95%CI: 0.9-1.8) | 1.9 (95%CI: 1.3-2.4) | 1.9 (95%CI: 1.4-2.5) | 3.0 (95%CI: 2.3-3.7) | 0.4 (95%CI: 0.1-0.6) | 1.1 (95%CI: 0.7-1.5) |
| 20-39 y *n*=907 | 70 (7.7) | 16 (1.8) | 21 (2.3) | 22 (9.4) | 32 (3.5) | 4 (0.4) | 8 (0.9) |
| 40-59 y *n*=1037 | 67 (6.5) | 8 (0.2) | 16 (1.5) | 15 (1.4) | 28 (2.7) | 1 (0.1) | 14 (1.3) |
| ≥60 y *n*=434 | 18 (4.1) | 4 (0.9) | 4 (0.9) | 5 (1.1) | 7 (1.6) | 3 (0.7) | 6 (1.4) |
| Males | | | | | | | |
| All males *n*=1397 | 86 (6.1) | 18 (1.3) | 19 (1.4) | 19 (1.4) | 47 (3.4) | 4 (0.3) | 9 (0.6) |
| Age-adjusted prevalence | 6.5 (95%CI: 5.2-7.8) | 1.4 (95%CI: 0.7-2.0) | 1.5 (95%CI: 0.8-2.1) | 1.5 (95%CI: 0.8-2.1) | 3.8 (95%CI: 2.8-4.8) | 0.3 (95%CI: 0.03-0.6) | 0.6 (95%CI: 0.1-1.0) |
| 20-39 y *n*=473 | 39 (8.2) | 8 (1.7) | 9 (1.9) | 8 (1.7) | 23 (4.9) | 2 (0.4) | 2 (0.4) |
| 40-59 y *n*=624 | 38 (6.1) | 6 (1.0) | 9 (1.4) | 8 (1.3) | 18 (2.9) | 1 (0.2) | 5 (0.8) |
| ≥60 y *n*=300 | 9 (3.0) | 4 (1.3) | 1 (0.3) | 3 (1.0) | 6 (2.0) | 1 (0.3) | 2 (0.7) |
| Females | | | | | | | |
| All females *n*=981 | 69 (7.0) | 10 (1.0) | 22 (2.2) | 23 (2.3) | 20 (2.0) | 4 (0.4) | 19 (1.9) |
| Age-adjusted prevalence | 6.9 (95%CI: 5.3-8.4) | 1.1 (95%CI: 0.4-1.8) | 2.3 (95%CI: 1.4-3.2) | 2.4 (95%CI: 1.5-3.4) | 2.0 (95%CI: 1.0-2.8) | 0.4 (95%CI: 0.02-0.8) | 1.8 (95%CI: 1.0-2.6) |
| 20-39 y *n*=434 | 31 (7.1) | 8 (1.8) | 12 (2.8) | 14 (3.2) | 9 (2.1) | 2 (0.5) | 6 (1.4) |
| 40-59 y *n*=413 | 29 (7.0) | 2 (0.5) | 7 (1.7) | 7 (1.7) | 10 (2.4) | 0 (0.0) | 9 (2.2) |
| ≥60 y *n*=134 | 9 (6.7) | 0 (0) | 3 (2.2) | 2 (1.5) | 1 (0.7) | 2 (1.5) | 4 (3.0) |

Age adjusted prevalence rate and 95% Confidence Interval (CI) is given only for overall subjects, all male and all female subjects

**Table 3: Association between risk factors and DED symptoms**

| Risk factor | One or more of the six symptoms of DED present often or all the time | | | |
|---|---|---|---|---|
| | Crude | | Adjusted odds ratio | |
| | Odds ratio (95% Confidence Interval) | *P* | Odds ratio (95% Confidence Interval) | *P* |
| Age | | | | |
| ≥60 years | 1.0 | | 1.01 (0.99-1.02) | 0.248 |
| 40-59 years | 1.60 (1.01-2.72) | 0.085 | | |
| 20-39 years | 1.93 (1.14-3.29) | 0.015 | | |
| Gender | | | | |
| Male | 1.0 | | 1.51 (1.06-2.16) | 0.021 |
| Female | 1.15 (0.83-1.60) | 0.394 | | |
| Smoking | | | | |
| No | 1.0 | | 1.09 (1.02-1.16) | 0.0008 |
| Yes | 1.08 (1.01-1.15) | 0.022 | | |
| Use of mobile phones/VDU | | | | |
| No | 1.0 | | 1.15 (1.08-1.22) | <.0001 |
| Yes | 1.11 (1.06-1.81) | <.0001 | | |
| Use of air-conditioning | | | | |
| No | 1.0 | | 1.06 (1.01-1.12) | 0.015 |
| Yes | 1.06 (1.01-1.12) | 0.013 | | |
| Level of education | - | - | | |
| Graduate/Post-graduate | | | 1.0 | |
| 12th pass | | | 1.08 (0.69-1.68) | 0.747 |
| 10th pass | | | 0.96 (0.56-1.63) | 0.868 |
| Middle | | | 1.21 (0.68-2.16) | 0.514 |
| Primary | | | 1.22 (0.59-2.50) | 0.590 |
| Illiterate | | | 1.17 (0.61-2.26) | 0.636 |
| Occupation | - | - | | |
| Unskilled laborer | | | 1.0 | |
| Semi-skilled laborer | | | 0.91 (0.32-2.59) | 0.864 |
| Skilled-laborer | | | 1.21 (0.64-2.29) | 0.561 |
| Clerical/shopkeeper/farmer | | | 0.65 (0.33-1.27) | 0.209 |
| Semi-profession | | | 1.35 (0.59-3.10) | 0.476 |
| Profession | | | 0.55 (0.24-1.27) | 0.126 |
| Unemployed | | | 0.71 (0.40-1.25) | 0.237 |

**Table 4: Prevalence of symptoms of dry eye disease in different population-based studies using only symptom questionnaire**

| Authors, Year, Country | Total subjects | Age in years | Type of questionnaire | Prevalence* |
|---|---|---|---|---|
| Bandeen-Roche *et al*., 1997, United States[17] | 2842 | ≥65 | Six-item | 15% |
| Lee *et al*., 2002, Indonesia.[9] | 1058 | ≥65 | Six-item | 27.5%(95%CI: 24.8-30.2) |
| Tong *et al*., 2009, Singapore.[20] | 3280 | 40-80 | Six-item | 6.5%(95%CI: 5.7-7.4) |
| Bakkar *et al*., 2016, Jordan.[10] | 1039 | ≥18 | OSDI | 59%† |
| Alshamrani *et al*., 2017, Saudi Arabia.[11] | 1858 | ≥16 | Six-item | 32.1%(95%CI: 30.4-34.3) |
| Graue-Hernandez *et al*., 2018, Mexico.[12] | 1508 | ≥50 | DEQ-5 | 41.1%(95%CI: 38.6-43.6)‡ |
| Castro *et al*., 2018, Brazil.[13] | 3107 | ≥18 | Three-item | 12.8% |
| Present study, 2020, India. | 2378 | ≥20 | Six-item | 6.8%(95% CI: 5.8-7.8) |

*Proportion of subjects reporting one or more symptoms in the six-item questionnaire; †proportion of subjects with Ocular Surface Disease Index® (OSDI) score ≥20; ‡proportion of subjects with Dry Eye Questionnaire-5 (DEQ-5) score ≥6.

in population, climate and degree of urbanization. It would be ideal if future population-based studies include at least one sign in its design, so as to provide a closer estimate of DED in India.

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### Conflicts of interest

There are no conflicts of interest.

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## Commentary: Impact of COVID-19 on ocular surface health

Dry eye is one of the most prevalent chronic ophthalmic conditions that adversely affects the quality and productivity of life.[1] Patients complaint of burning sensation, foreign body sensation or grittiness, photophobia watering, and blurry vision leading to significant difficulties in carrying out daily routine activities. The condition is multifactorial, chronic and is characterized by a vicious cycle of ocular surface inflammation and its adverse effect on ocular surface health.[2] As we may have observed, the flow of patients suffering from this condition is ever increasing in our practice; thus, to estimate the true prevalence of this condition from a population-based study is the need of the hour. With the advent of novel coronavirus 2019 (COVID-19) global pandemic, the situation has only worsened.

Over 50 million people across the world and close to 8.9 million people in India have been afflicted by the COVID-19 till date.[3] The pandemic has ushered in a way of life that has led people to spend most of their time indoors while still carrying out their work and education through visual display terminal (VDT). Concepts such as work from home and online classes have become the new norm and as definitive cure or vaccine are still eluding us; this novel way of life is likely to persist. Screen time has replaced the time which was otherwise spent doing outdoor activities leading to an increase in ocular symptomatology particularly dry eye disease (DED).

In a questionnaire-based survey conducted by a teaching hospital in Italy in COVID era, 24.3% respondents reported having used VDT in the last month for >6 h daily, while 67.3% reported to have worn face mask >6 h daily.[4] A percentage of 10.3 of subjects described appearance or worsening of ocular discomfort symptoms, and 19.6% reported the need for daily