Research Article

Prevalence of dry eye disease in Riyadh, Saudi Arabia: A population-based survey OSDI of young adults aged 16–39 years

Dr. Haya M. Al-Farhan[1] and Abrar Al Salloum[1]
[1]Optometry Department, College of Applied Medical Sciences, Riyadh, Kingdom of Saudi Arabia King Saud University, Riyadh, Kingdom of Saudi Arabia.

Correspondence: Haya M. Al-Farhan,
Optometry Department, College of Applied Medical Sciences, Riyadh, Kingdom of Saudi Arabia King Saud University, Riyadh, Kingdom of Saudi Arabia;
halfarhan@ksu.edu.sa

Received: September 22, 2023
Accepted: September 30, 2023

Objective: Dry eye disease is a multifactorial disease that adversely impacts the quality of life. The study helped by performing an exhaustive analysis of participants' responses during the coronavirus lockdown in Riyadh. The study aimed to gather evidence by incorporating an ocular surface disease index (OSDI) questionnaire in a healthy population. The questionnaire helped find the DED severity based on age, gender, and demographic information.

Methods. A cross-sectional (OSDI) survey was led among healthy male and female participants in Riyadh from March 2021 to March 2022. This study helped study the change of environment and lifestyle through the questionnaire.

Results. 611 participants, having a mean age of 26, were chosen for the survey. The DED prevalence among respondents was 68.58%. The OSDI scores significantly differed between female and male participants. The most difference in severity was reported among respondents of age groups (16–26 and 27–39 years). The scores were significantly higher for female participants.

Conclusions. The overall prevalence of dry eyes was 68.58% during the COVID-19 pandemic. DED was higher among the age group of 16–26, and the occurrence was mainly frequent among female respondents. Eye healthcare systems should gather more evidence to increase awareness in young adults to prevent them from contracting DED, which places a considerable financial burden on healthcare systems.

Keywords: Prevalence, Healthy, OSDI, COVID-19, Riyadh

Background

DED is recognized worldwide as a genetic illness of the tear and ocular surface, associated with hyperosmolarity of the tear film. It leads to inflammation in the eye and is often accompanied by symptoms of discomfort, fatigue, and blurred vision[1]. The prevalence of DED ranges from 5.25% to 62.6%[2,3]. The variation is prevalent due to differences in geographical location, population, diagnostic techniques, race, and subject criteria. For example, the prevalence of DED in Asian countries ranges from 20% to 52.4%, more significant than that in Western countries, ranging from 7.6% to 16.2%.[4]

Previous studies used the (OSDI) questionnaire {3-5], to investigate the prevalence of DED. The OSDI questionnaire is used as a clinical means to determine DED prevalence and assess the symptom severity of DED. Its simplicity, repeatability, reliability, robustness, and validity are well documented[5]. It assesses DED symptoms, vision-related functions, and environmental triggers[5]. The effect of DED is essentially significant to measure the patient's quality of life, lifestyle, and the burden it imposes on healthcare systems. For example, the annual cost of managing DED in the USA is $55.4 billion[6]. Recent studies report that the prevalence of DED in the age group of 17–29 years ranges from 38% to 59%[3-7]. This study analyzed the participant's performance and response during the coronavirus lockdown in Riyadh. The research aimed to estimate the occurrence of dry eye among the respondents. The research was conducted using a healthy population survey questionnaire. The questionnaire helped compare estimated prevalence of the degree of severity in dry eyes based on age- and sex-related factors. The questionnaire also helped compare participants' responses to the frequency, intensity, and occurrence of OSDI symptoms based on their age, sex, lifestyle, locality, and environmental settings. The OSDI questionnaire was incorporated for the study to help get a clear insight into the severity of the disease in the respondents who volunteered for the survey, keeping complete privacy and confidentiality of their individuality. The OSDI application helped reach out to the maximum of respondents through the IOS and Android mobile application, made available by the author and co-author of the research study to cover many respondents who wished to participate in the survey. This survey has helped the eye healthcare systems project a greater perspective of the disease and help find a cure, whether genetic or infused through the environmental system, lifestyle, or otherwise.

The (16–26) years and (27–39) years of age groups represent the young adult's population, in Riyadh. The OSDI questionnaire was incorporated to analyze these age groups' responses during the COVID-19 lockdown. During

iovs.arvojournals.org | ISSN: 1552-5783

the COVID-19 restrictions, all participants aged 16–39 were obligated to attend classes and perform online educational tasks or professional work tasks from home. Most of the generation was seen using social media to either cater their entertainment needs or professional work. The OSDI application also quested to infer the impact of corona virus on the respondents and the severity of dry eyes, given that the environment had contracted a viral infection that must've sensitized the prevalence of dry eyes, the intensity, and the occurrence of the disease. The use of social applications for entertainment has led to an increased duration of screen time that has adversely affected the respondents with whom the occurrence of the disease was adverse and concurrent. Studies have reported that intense use of visual displays that can diminish the blink frequency or cause incomplete blinking, leading to tear film instability, mild epithelial damage, DED symptoms, partial blindness, or color blindness[8,9,10].

METHODS

This cross-sectional and exhaustive study was conducted in the year, March' 2021 to March' 2022. The OSDI questionnaire were used in two locations. The respondents were selected from King Saud University's campus clinic and the Kingdom Hospital in Riyadh, Saudi Arabia. A total of 611 participants aged between 16–39 years who visited the two locations were selected by a systematic random sampling technique. The inclusion criteria were individuals with healthy lifestyles, non-contact lens wearers, those with no previous history of systemic medication, ocular diseases, or refractive or Lasik surgeries[4].

The sample calculation was performed using an online sample size software (Available at http://sampsize.sourceforge.net/iface/#prev) for prevalence studies. Considering our population to be infinite, the questionnaire was distributed to participants living in Riyadh. Considering a 95% confidence level and 0.05 as the degree of freedom, a DED prevalence of 70% was noted to be of respondents who were consistent computer users. The study has an accuracy of 5%. The sample size hence calculated was 323 participants. Based on the sample size, a minimum of 646 participants were needed for both age groups, comprising males and females, respectively. The 27–39 did not take part in the study.

The questionnaire was conducted using the OSDI application. Allergan, Inc. OSDI questionnaire application could be easily downloaded from the Apple store on the iPad for free. As reported in the literature survey, the application was made to cater to audiences of mature age groups and those with the accession of social media. The time frame was around the COVID-19 lockdown since most professionals and college/university-going students were seen to be using mobile phones more often than normal. Hence, it increased the respondent's screen time, so the occurrence of dry eyes, genetic or otherwise, was due to contract. The questionnaire application allows users to export the questionnaire results. The co-author, A.S., presented an Apple iPad to the participants and waited to address the participant's doubts until they completed answering the questionnaire. Then, the data collected was exported into an Excel sheet

The OSDI is valid and reliable and the most widely used tool to discriminate between healthy participants and those with DED, and to measure the severity of DED. It contains 12 questions and is divided into three parts. The first five questions pertain to symptom frequency, the next four pertain to vision-related quality of life, and the last three pertain to the environmental triggers for a 1-week recall period. The OSDI score can range from 0 to 100 where (0–12) is normal, (13–22) is mild dry eye severity, (23–32) is moderate dry eye severity, and (33–100) is severe dry eye severity [5]. Each answer is scored using a 5-point Likert scale where 0 indicates no symptoms and 4 indicates significant symptoms. The following formula calculated the actual score of the severity.

OSDI = (sum of scores for all questions answered × 25)/(total number of questions answered × 4).

The quantitative approach was utilized in the cross-sectional survey to conduct and collect data from the respondents, engaging the use of the SPSS statistics software. This helped bring clear and significant results among the severity of dry eyes in the respondents, corresponding to the difference of age groups, gender, locality, lifestyle and other related demographics constraints. Different tests have been generated including Chi Square, Pearson correlation, T-tests, standard deviation and means. The generated tables have been analysed to gauge the response of the respondents effectively to meet the desired outcomes of the study.

Ethical Considerations

This study was approved by the King Saud University Research Ethics Committee (approval no. E-21-5731 KSU). It was conducted in the Department of Optometry and Visual Science, College of Applied Medical Sciences, King Saud University and Kingdom Hospital, Riyadh, Saudi Arabia. The participants provided written consent and could withdraw at any time. The study adhered to the tenets of the Declaration of Helsinki.

Statistical analysis

The data were analyzed using the Statistical Package for Social Sciences software (SPSS), version 28.0 (SPSS Inc, Chicago, II, USA). Data was described and interpreted using means, standard deviations, and percentages. Average OSDI scores were evaluated by age, gender, locality and lifestyle. A t-test compared continuous variables. Chi-square tests were used for comparisons between categorical variables. Hypothesis was created over the ideology of the percentage of respondents, based on gender who have the severity of dry eyes and the accentuated age group who has contracted the maximum thrash of the disease. The P-value of <0.05 at a confidence level of 95% was considered statistically significant.

RESULTS

A total of 611 participants were enrolled after completing their questionnaire. The enrolled participants' supported data is provided in Table 1.

TABLE. 1 Number of participants with age (mean standard deviation [SD] and median [interquartile range, IQR]) and sex data.

Parameters	16–39 year	16–26 years	27–39 years
Number of participants	611	361	250
Age (mean SD)	26.09±6.43	21.49±2.44	32.22±4.20
Female	25.52±6.25	21.47±2.36	32.67±4.25
Male	27.16±6.64	21.53±2.62	32.85±4.15
Sex (%)			
Female	65.12%	70.36%	57.60%
Male	34.86%	29.64%	42.40%
Age (median [IQR])			
Female	21	21	32
Male	32	22	32

The total prevalence of DED among all participants according to the OSDI questionnaire was 68.58%. DED severity differed significantly between female and male participants within the whole group aged 16–39 years (P<0.001). The total prevalence of DED among female and male participants in the 16–26 age group according to the OSDI was 54.85% and 16.89%, respectively. The p- value was noted to be less than 0.001. The total prevalence of DED according to the OSDI among female and male participants within the 27–39 age group was 41.21% and 22.8%, respectively, and having a p-value of 0.001. Moreover, a comparison based on age and DED severity indicated significant differences between the two age groups. This comparison was denoted by the p-value, which was measured to be less than 0.003. The results of the chi-square test and correlations between the factors age, sex, and OSDI DED severity degree are illustrated in Table 2.

Figure 1. The OSDI score distribution based on age groups and DED severity degree

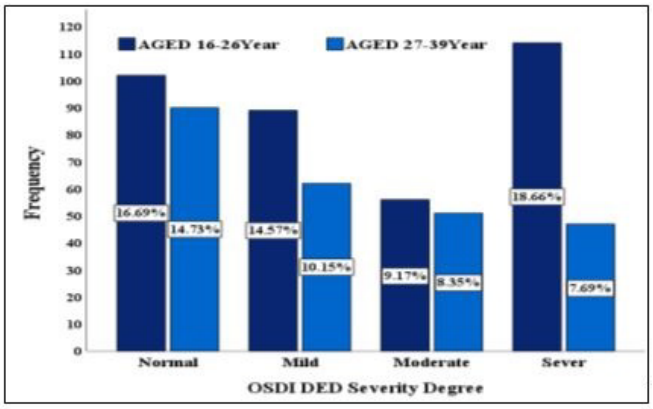

Table. 2 The comparison results of the prevalence of OSDI severity degree based on age and sex, using the chi-square test and Spearman correlations

OSDI degree		Normal	Mild	Moderate	Severe	†P-value	‡ r / P-value
Group (16–39)	T	31.43%	24.72%	17.51%	26.35%	<0.001*	0.21 /<0.001*
	M	15.55%	7.86%	5.56%	5.89%		
	F	15.88%	16.86%	11.95%	20.46%		
Within age groups							
Group (16–26)	M	12.74%	7.20%	2.49%	7.20%	<0.001*	0.20 / <0.001*
	F	15.51%	17.45%	13.02%	24.38%		
Group (27–39)	M	19.60%	8.80%	10%	4%	0.001*	0.20 / 0.002*
	F	16.40%	16%	10.40%	14.80%		
Between age groups							
Group (16–26)		16.69%	14.57%	9.17%	18.66%	0.003*	-0.12 / 0.003*
Group (27–39)		14.72%	10.15%	8.35%	7.69%		

T = Total, Male=M, Female =F, †chi-square, ‡Spearman correlation * Statistically significant

The comparison of average OSDI scores of the 16–39 age group revealed that the average OSDI scores were higher among female individuals than male individuals, having P-value less than 0.001 (P<0.001) and higher in the 16–26 age (P<0.001) (Figure 1). The average OSDI scores were also higher for female participants within both age groups (P<0.001) (Table 3

Table. 3 The comparison results of the average score OSDI of dry eye based on age and sex using t-test.

OSDI score		Mean±SD	MDif	95% CI	P-value
Group (16–39)		23.58±17.04	------	22.22, 24.93	----
Group (16–39)	M	18.68	7.49	4.79, 10.20	<0.001
	F	26.16			
		Age			
Group (16–26)		25.40±18.21	5.3	2.6, 8.03	<0.001
Group (27–39)		20.10±14.84			
		Sex			
Group (16–26)	M	19.15±17.22	8.90	4.0, 12.89	<0.001
	F	28.03±17.99			
Group (27–39)	M	18.34±13.86	4.54	1.98, 7.10	<0.001
	F	22.88±15.27			

Male=M, Female =F, MDif = Mean difference, CI=confidence interval, SD= Standard deviation

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The comparison of responses of both age groups to the questions in the OSDI questionnaire for DED severity differed significantly for the following questions:

- Eyes feel gritty (P=0.016).
- Poor vision (P=0.0001).
- Watching TV (P=0.05).
- Windy conditions (P=0.014).

The correlation was significant, although weakly positive, except for the windy conditions question. The correlation result is extensively laid out in Table 4, Figure 2

Table. 4 Comparison of responses of both age groups to OSDI questions on symptom frequency and intensity based on age and OSDI dry eye severity using the chi-square test and Spearman correlations.

Comparison between age groups (16–26) and (27–39)		
OSDI questions	**†P value**	**‡ r / P-value**
1. Eyes sensitive to light	0.45	-0.04 / 0.37
2. Eyes that feel gritty	0.016*	0.10 /0.016*
3. Painful eyes	0.10	0.10 / 0.11
4. Blurred vision	0.14	0.10 / 0.18
5. Poor vision	0.0001*	0.20 / 0.0001*
6. Reading	0.063	0.10 / 0.03*
7. Driving at night	0.15	0.23 / 0.56
8. Working with computer or ATM	0.63	0.1 / 0.16
9. Watching TV	0.05*	0.10 / 0.044*
10. Windy conditions	0.014*	0.01 / 0.75
11. Areas with low humidity	0.18	0.50 / 0.27
12. Areas with air conditioned	0.35	0.021 / 0.61

†chi-square, ‡Spearman correlation * Statistically significant

FIGURE 2. The OSDI score distribution based on age groups and DED severity degree

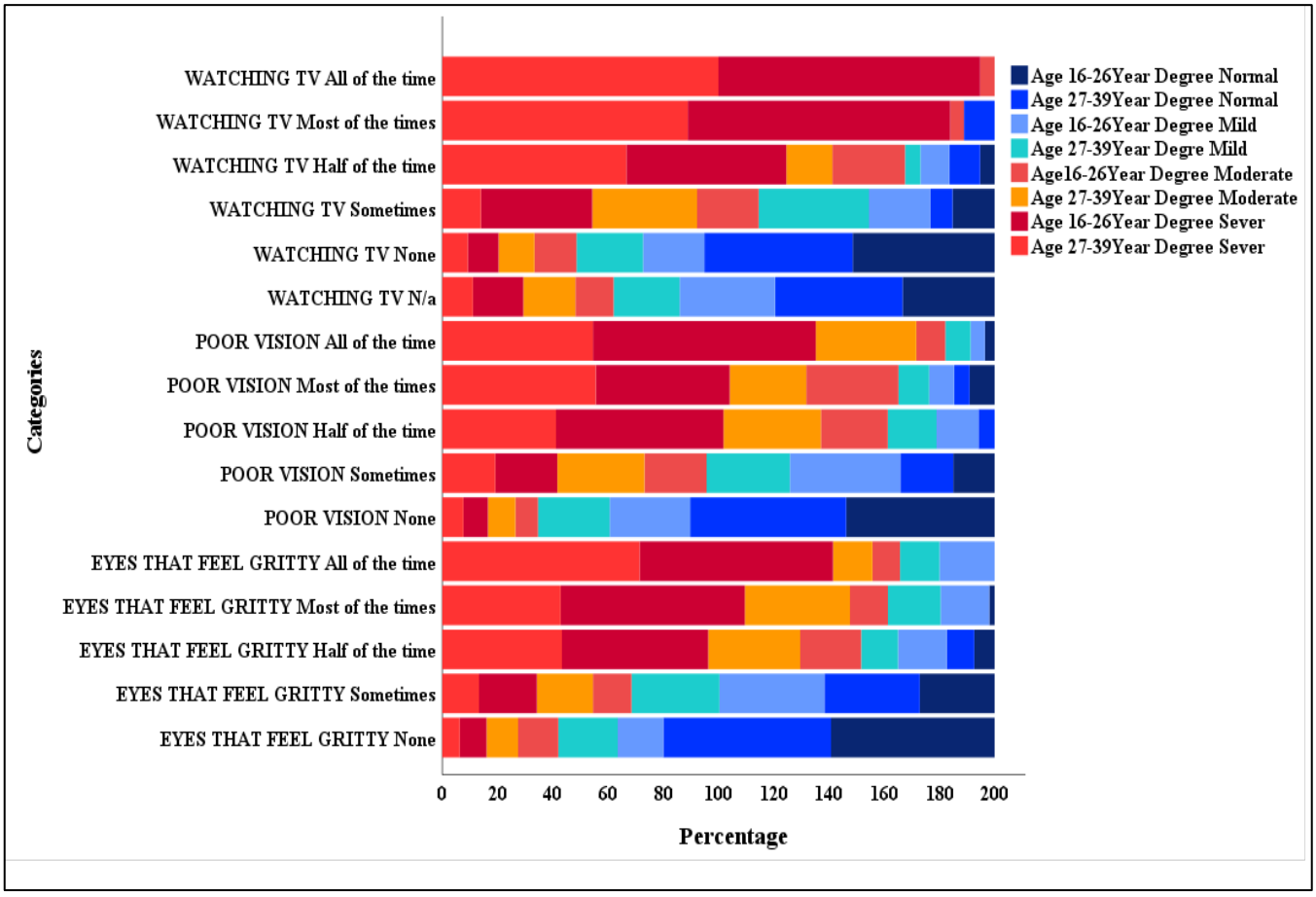

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Table. 5 Responses of the 16–39 age group to OSDI questions on symptom frequency and intensity based on sex and OSDI dry eye severity degree using the chi-square test and Spearman correlations

Group (16–39)	Response	Normal	Mild	Moderate	Severe	†P value	‡ r / P-value
Sex	**1. Eyes sensitive to light**						
Male	Never	30.0%	9.90%	2.30%	4.20%	<0.001*	0.52 / <0.001*
	Sometimes	11.70%	9.40%	7.50%	5.60%		
	Half of the time	2.80%	1.40%	4.20%	3.30%		
	Most of the time	0.0%	1.40%	0.90%	3.30%		
	All the time	0.0%	0.50%	0.90%	0.50%		
Female	Never	17.60%	11.10%	5.50%	3.30%		
	Sometimes	6.30%	10.60%	10.10%	11.60%		
	Half of the time	0.50%	3.0%	1.50%	6.0%		
	Most of the time	0.0%	1.30%	1.30%	7.30%		
	All the time	0.0%	0.0%	0.0%	3.30%		
	2. Eyes that feel gritty						
Male	Never	27.20%	4.20%	2.80%	0.90%	<0.001*	0.52 / <0.001*
	Sometimes	16.0%	14.10%	5.60%	6.10%		
	Half of the time	1.40%	1.90%	3.80%	6.60%		
	Most of the time	0.0%	1.90%	3.80%	2.80%		
	All the time	0.0%	0.50%	0.0%	0.50%		
Female	Never	12.80%	6.30%	4.50%	3.30%		
	Sometimes	10.10%	13.80%	7.30%	7.30%		
	Half of the time	1.30%	3.0%	4.30%	8.80%		
	Most of the time	0.30%	2.30%	1.80%	9.30%		
	All the time	0.0%	0.50%	0.50%	2.80%		
	3. Painful eyes						
Male	Never	42.30%	16.0%	6.10%	8.90%	<0.001*	0.46 / <0.001*
	Sometimes	1.90%	5.60%	6.60%	3.30%		
	Half of the time	0.50%	0.50%	2.80%	2.30%		
	Most of the time	0.0%	0.50%	0.50%	2.30%		
	All the time	0.0%	0.0%	0.0%	0.0%		
Female	Never	23.40%	18.60%	10.60%	13.30%		
	Sometimes	1.0%	6.30%	6.30%	8.0%		
	Half of the time	0.0%	1.0%	0.80%	4.80%		
	Most of the time	0.0%	0.20%	0.70%	3.80%		
	All the time	0.0%	0.0%	0.0%	0.5%		
	4. Blurred vision						
Male	Never	36.60%	12.20%	6.10%	6.10%	<0.001*	0.59 / <0.001*
	Sometimes	7.50%	9.90%	7.50%	5.60%		
	Half of the time	0.50%	0.0%	0.90%	1.90%		
	Most of the time	0.0%	0.50%	1.40%	2.30%		
	All the time	0.0%	0.0%	0.0%	0.90%		
Female	Never	18.80%	13.10%	5.80%	2.50%		
	Sometimes	5.30%	10.10%	6.80%	9.80%		
	Half of the time	0.30%	2.30%	4.50%	8.80%		
	Most of the time	0.0%	0.50%	1.30%	7.30%		
	All the time	0.0%	0.0%	0.0%	3.0%		
	5. Poor vision						
Male	Never	37.6%	9.40%	4.70%	2.80%	<0.001*	0.60 / <0.001*
	Sometimes	6.60%	10.30%	8.0%	4.20%		
	Half of the time	0.0%	0.90%	1.90%	2.30%		
	Most of the time	0.50%	1.40%	1.40%	3.30%		
	All the time	0.0%	0.50%	0.0%	4.20%		
Female	Never	19.80%	15.10%	4.0%	4.50%		
	Sometimes	3.0%	8.0%	6.0%	5.80%		
	Half of the time	0.30%	1.50%	2.50%	5.50%		
	Most of the time	0.80%	0.50%	3.30%	4.80%		
	All the time	0.50%	0.80%	2.50%	10.80%		

†chi-square, ‡Spearman correlation * Statistically significant

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Table. 6 Responses of the 16–39 age group to OSDI questions on vision-related function symptoms based on sex and OSDI dry eye severity using the chi-square test and Spearman correlations

Group (16–39)	Response	Normal	Mild	Moderate	Severe	†P value	‡ r / P-value
Sex	**6. Reading**						
Male	N/A	25.80%	14.10%	6.60%	5.60%	<0.001*	0.42 / <0.001*
	Never	16.90%	5.60%	5.20%	1.90%		
	Sometimes	1.40%	2.30%	3.80%	4.20%		
	Half of the time	0.50%	0.0%	0.0%	1.90%		
	Most of the time	0.0%	0.50%	0.50%	0.90%		
	All the time	0.0%	0.0%	0.0%	2.30%		
Female	N/A	15.60%	16.60%	11.30%	10.80%		
	Never	7.30%	4.30%	2.30%	2.50%		
	Sometimes	1.50%	4.80%	4.0%	8.50%		
	Half of the time	0.0%	0.30%	0.30%	4.50%		
	Most of the time	0.0%	0.0%	0.50%	3.0%		
	All the time	0.0%	0.0%	0.0%	2.0%		
7. Driving at night							
Male	N/A	26.30%	12.70%	5.60%	5.20%	<0.001*	0.24 / <0.001*
	Never	16.0%	5.60%	4.20%	0.90%		
	Sometimes	0.90%	3.80%	3.30%	1.90%		
	Half of the time	0.90%	0.0%	1.90%	2.80%		
	Most of the time	0.50%	0.0%	0.50%	3.30%		
	All the time	0.0%	0.50%	0.50%	2.80%		
Female	N/A	16.60%	20.60%	12.80%	20.40%		
	Never	7.30%	4.0%	1.8%	6.0%		
	Sometimes	0.50%	1.0%	2.50%	2.30%		
	Half of the time	0.0%	0.30%	0.50%	0.80%		
	Most of the time	0.20%	0.0%	0.30%	2.10%		
	All the time	0.0%	0.20%	0.50%	1.30%		
8. Working with computer OR ATM							
Male	N/A	23.90%	12.20%	6.10%	6.10%	<0.001*	0.46 / <0.001*
	Never	18.80%	3.80%	0.90%	0.90%		
	Sometimes	1.40%	5.20%	5.60%	2.80%		
	Half of the time	0.5%	0.0%	2.80%	2.30%		
	Most of the time	0.0%	1.40%	0.0%	2.80%		
	All the time	0.0%	0.0%	0.50%	1.90%		
Female	N/A	14.60%	14.30%	7.30%	8.30%		
	Never	7.0%	3.0%	2.30%	2.50%		
	Sometimes	2.80%	7.0%	6.0%	8.0%		
	Half of the time	0.0%	1.0%	2.0%	4.0%		
	Most of the time	0.0%	0.30%	0.30%	5.30%		
	All the time	0.0%	0.30%	0.50%	3.30%		
9-Watching TV							
Male	N/A	23.50%	12.20%	5.20%	4.20%	<0.001*	0.50 / <0.001*
	Never	16.90%	4.70%	4.20%	0.50%		
	Sometimes	3.30%	5.60%	6.10%	3.30%		
	Half of the time	0.50%	0.0%	0.50%	1.40%		
	Most of the time	0.50%	0.0%	0.0%	3.80%		
	All the time	0.0%	0.0%	0.0%	3.80%		
Female	N/A	14.30%	14.30%	8.30%	8.30%		
	Never	7.50%	4.80%	2.30%	3.0%		
	Sometimes	2.0%	6.0%	5.50%	7.30%		
	Half of the time	0.50%	0.80%	1.80%	5.0%		
	Most of the time	0.0%	0.0%	0.30%	4.80%		
	All the time	0.0%	0.0%	0.30%	3.0%		

†chi-square, ‡Spearman correlation * Statistically significant

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Table. 7 Responses of the 16–39 age group to OSDI questions on environmental triggers based on their sex and OSDI dry eye severity degree using the chi-square test and Spearman correlations

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Group 16–39	Response	Normal	Mild	Moderate	Severe	†P value	‡ r / P-value
Sex	**10. Windy conditions**						
Male	N/A	20.20%	7.0%	3.30%	2.30%		
	Never	13.60%	5.20%	2.30%	0.50%		
	Sometimes	10.3%	8.0%	3.80%	4.70%		
	Half of the time	0.50%	1.40%	2.80%	2.80%		
	Most of the time	0.0%	0.90%	2.80%	5.20%		
	All the time	0.0%	0.0%	0.90%	1.40%		
Female	N/A	10.60%	5.50%	5.50%	7.0%	<0.001*	0.46 / <0.001*
	Never	8.50%	3.0%	1.50%	1.50%		
	Sometimes	4.30%	14.30%	7.50%	7.50%		
	Half of the time	1.0%	2.0%	2.50%	4.50%		
	Most of the time	0.0%	1.0%	1.0%	4.50%		
	All the time	0.0%	0.0%	0.30%	6.30%		
	11. Areas with low humidity						
Male	N/A	25.80%	11.30%	4.70%	6.10%		
	Never	15.0%	5.60%	5.20%	1.90%		
	Sometimes	3.30%	5.20%	4.20%	5.60%		
	Half of the time	0.50%	0.50%	1.40%	0.90%		
	Most of the time	0.0%	0.0%	0.50%	1.90%		
	All the time	0.0%	0.0%	0.0%	0.50%		
Female	N/A	15.10%	13.60%	8.30%	11.80%	<0.001*	0.40 / <0.001*
	Never	8.50%	6.80%	4.30%	3.50%		
	Sometimes	0.80%	4.30%	4.0%	8.0%		
	Half of the time	0.0%	1.0%	1.80%	4.80%		
	Most of the time	0.0%	0.30%	0.0%	1.50%		
	All the time	0.0%	0.0%	0.0%	1.80%		
	12. Areas with air conditioning						
Male	N/A	21.60%	7.50%	4.20%	3.80%		
	Never	17.80%	7.0%	3.30%	0.90%		
	Sometimes	4.20%	6.60%	5.60%	3.30%		
	Half of the time	0.90%	0.50%	2.30%	4.20%		
	Most of the time	0.0%	0.50%	0.0%	2.80%		
	All the time	0.0%	0.50%	0.50%	1.90%		
Female	N/A	12.30%	6.30%	6.80%	6.80%	<0.001*	0.46 / <0.001*
	Never	8.50%	4.0%	2.50%	3.30%		
	Sometimes	3.30%	12.60%	4.50%	5.30%		
	Half of the time	0.30%	2.0%	3.80%	6.80%		
	Most of the time	0.0%	1.0%	0.80%	4.80%		
	All the time	0.0%	0.0%	0.0%	4.50%		

†chi-square, ‡Spearman correlation * Statistically significant

Discussion

This study evaluated the current estimate for DED prevalence for the young adult's in Riyadh, representing healthy Saudi participants, aged between 16–39 years. These results help to categorize and to characterize the individuals in this subgroup who are at an emergent risk of DED occurrence. This study also compares participants' responses to the OSDI questionnaire based on age, sex, and DED severity based of classifications and related demographic information.

Comparing the DED prevalence observed in this study to that in previous literature for similar age groups is potentially difficult due to reasons such as, the adoption of survey methodologies, environmental conditions and locality, sample size, race, and variations in participants' health conditions[2,11,12]. Nonetheless, highlighting previous studies' findings is helpful for researchers to conduct further implications of the study, in order to draw limitations of the research conducted.

The OSDI inferred a total prevalence of 68.58% DED in the 16–39 age group. The research findings show that the DED prevalence according to the OSDI questionnaire was higher in women, (49.27%) than in men, (19.31%). There was a statistically significant difference in the OSDI-derived prevalence of DED between different genders. Further, the research outcomes show that the DED prevalence according to the OSDI questionnaire was higher in women than men within both age groups. It is well documented that the prevalence of DED was higher in women than in men before the COVID-19 pandemic. Hence, the time frame taken to conduct the research was carefully sought to analyze the sensitivity of the prevalence of DED as a disease among the respondents[11,12,13,14,15,16,17,18].

Moreover, during the COVID-19 pandemic, several studies have documented similar findings, especially in young adults[16,19]. For instance, (Garg et al., 2022) reported that among 18–40-year-olds, 56.1% of women and 43.90% of men had contracted DED during COVID-19. (Lin et al., 2022) stated that women showed a higher risk of about 1.25-fold of having DED than men in the 14–19-year age group.

The female sex has been documented as having potential repercussions from DED in many studies. It was mainly due to the presence of androgens and oestrogens, imbalanced menstrual cycles, and child expectancy, that affects ocular stability. Low androgen level was a consistent risk factor for DED among many studies[21,22,23]. In addition, the lifestyle of younger women and the continuous use of mobile devices for entertainment tasks or otherwise can contribute as the potential risk factors for DED[12,13]. In contrast, (Craig, Jennifer P. et al., 2017), reported that the prevalence of DED was more frequent in women than in men and gradually increases with age. However, they recommend that the future research must include a better evaluation of the prevalence of DED of varying severities among youths from different populations and localities[24].

The prevalence of DED in the (16–26) year age group was 42.40%, as opposed to that of in the 27–39-year age group (26.19%). According to the OSDI questionnaire, a significant difference between the OSDI-assessed prevalence of DED in

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the two age groups. The increase in the prevalence of DED with age has been well documented [1,24]. However, (Caffery B et al., 2019) explained, using DEWS II meta-analysis, that the individuals prevalent in DED were aged 18–24 years. Theyear age was comparable to that in individuals aged ≥45 years and is higher than in individuals aged 25–44. This comparison is due to the lower sample size in the 18–24-year age group, precisely (n = 279 vs 25–44 years, where n = 1810, among individuals who have crossed the 45-year mark, also corresponding to n = 3074). The random error was due to a sufficient increase in the DED prevalence among this age group[11].

Recently, several studies reported a higher prevalence of dry eye in young adults. For example, (Hu et al., 2022), said that the prevalence of DED, obtained using the OSDI, for the age groups 20–29, 30–39, and 40–49 years was 41%, 34%, and 42.50%, respectively. This may be due to various risk factors, such as lifestyle-associated factors, and the widespread use of visual displays, i.e., computers and mobile devices, especially among younger individuals. Such lifestyles imply the risk of DED[13]. This is reportedly associated with poor blinking habits, which cause meibomian gland dysfunction and dropout and tear film instability[13]. In addition, restrictive measures for social interaction during the COVID-19 lockdown have caused this age group to attend online classes from home, and hence, increased their use of display devices for educational and professional tasks. Furthermore, wearing facemasks is being strongly encouraged to help combat the spread of COVID-19[26,27]. During the pandemic, it was mandatory to wear face masks, especially when outdoors. This has led toward the consideration of face masks as a risk factor for DED, owing to poor fitting masks and air leak[28]. (Dikmetaş Ö et al., 2023), Reported that the use of face masks decreased ocular surface staining even in respondents. Further studies should study the occurrence of tear film after the use of mask for an extended period.

The average OSDI scores were significantly higher among females than males within both age groups, supporting previous observations[23,25]. This might be due to low androgen levels[29,30]. Another risk factor associated with female individuals may be the use of cosmetics near the eyes, which could disrupt the homeostasis of the ocular surface and tear film, both directly and indirectly[31].

In terms of age, the average OSDI scores were significantly higher in the 16–26 age group than in the 27–39 age group due to the high degree of DED severity in the 16–26 age group, which was double the 27–39 age group (Figure 1). Our finding supports previous reports that an increased use of display devices was positively correlated with higher OSDI scores. Reducing blink frequency and incomplete blinking during electronic device use contribute to accelerated evaporation, leading to tear film instability and dry eye symptoms[8,9,32,33].

Our results for both age groups' responses to OSDI questions for DE severity indicated that the 16–26 age group had significantly higher percentages of 'all the time', 'most of the time', and 'half of the time' responses, as DE severity increased, particularly for the following symptoms:

- Gritty eye feeling
- Poor vision, and watching TV.

Our evaluation of OSDI DE severity and its relation to sex in both age groups revealed that DED severity classification was mainly driven by female individuals, as their responses of 'half of the time', 'most of the time high', and 'all the time' increased as the degree of DED severity increased, and the sex differences in responses to OSDI questions were significant. The correlations ranged from moderate to weak and differed significantly between the sexes. This is the only study that has analyzed responses at this depth, and there are no previous studies for comparison.

Limitations

This study's limitation was that we could not conduct clinical tests due to the COVID-19 lockdown measures and that we did not collect pre-COVID data. Our future research will include clinical tests for dry eye, the economic burden due to DED in Saudi Arabia, and DED's effect on organizations employee's performance.

Conclusion

The overall prevalence of DED in the healthy group in Riyadh, aged 16–39 years, was 68.58% during the COVID-19 pandemic. DED was higher in the 16–26 age group and female individuals than in male individuals. A higher proportion of female individuals mainly drove the higher responses to the OSDI questionnaire. Eye healthcare providers must increase awareness of DED symptoms and complications for young adults to prevent acute DED from becoming chronic, which places a considerable financial burden on healthcare systems.

List Of Abbreviations

COVID-19: Coronavirus Disease
DED: Dry Eye Disease
IQR: Interquartile range
OSDI: Ocular Surface Disease Index
SD: Standard Deviation.

Declarations

Ethics approval and consent to participate

This study was approved by the King Saud University Research Ethics Committee (approval no. E-21-5731 KSU). It was conducted in the Department of Optometry and Visual Science, College of Applied Medical Sciences, King Saud University and Kingdom Hospital, Riyadh, Saudi Arabia. The participants provided written informed consent and had the right to withdraw from the study at any time. The study adhered to the tenets of the Declaration of Helsinki " in ethics approval and consent to participate section.

Consent for publication

Not Applicable

Availability of data and materials

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding

This research received no financial or grant from any funding agency in the public, commercial, or not-for-profit sectors and/or publication of this article.

Authors' contributions

H.A.F. conceived and designed the study, performed data collection and analysis, and wrote the manuscript. A.A.S., being the co-author, performed the data collection and analysis. All authors read and approved the final manuscript. The data analysis hence performed is in good correlation with

the argument and proves the stance of the research well. The data analysis, hereby conforms to the study and is a viable resource for future research in the respective topic.

Authors' Information

Dr. Haya Alfarhan is currently an Associate Professor at the College of Applied Medical Sciences, King Saud University in Riyadh. She obtained her PhD in optometry from City University of London: UK, and participated in several high-profile conferences. In addition to her academic career, Dr. Haya has held several managerial positions in Saudi Arabia. Her credibility in the research has proved to be a valuable asset to the research community across Riyadh and beyond. Her study for the aforementioned topic has proved to serve as a research breakthrough for researchers who wish to devote their findings to the study.

References

1. Craig JP, Nichols KK, Akpek EK, Caffery B, Dua HS, Joo CK, et al. TFOS DEWS II Definition and Classification Report. Ocul Surf. 2017;276-83.
2. Dana R, Bradley JL, Guerin A, Pivneva I, Stillman IÖ, Evans AM. Estimated prevalence and incidence of dry eye disease based on coding analysis of an extensive, all-age United States health care system. *Am J Ophthalmol*. 2019;202:47-54.
3. Alkabbani S, Jeyaseelan L, Rao AP, Thakur SP, Warhekar PT. The prevalence, severity, and risk factors for dry eye disease in Dubai – a cross-sectional study. BMC Ophthalmol. 2021;21:219.
4. Stapleton F, Alves M, Bunya VY, Jalbert I, Lekhanont K, Malet F, et al. TFOS DEWS II epidemiology report. Ocul Surf. 2017;15:334-65.
5. Schifan RM, Christianson MD, Jacobsen C, Hirsh D, Meis L. Reliability and validity of the Ocular Surface Disease Index. Arch Ophthalmol. 2000;118:615-21.
6. Yu J, Asche CV, Fairchild CJ. The economic burden of dry eye disease in the United States: a decision tree analysis. Cornea. 2011;30:379-87.
7. Shanti Y, Shehada R, Bakkar MM, Qaddumi J. Prevalence and associated risk factors of dry eye disease in 16 northern West bank towns in Palestine: a cross-sectional study. BMC Ophthalmol. 2020;20:26.
8. Chu CA, Rosenfield M, Portello JK. Blink patterns: reading from a computer screen versus hard copy. Optomet Vis Sci. 2014;91:297-302.
9. Argilés M, Cardona G, Pérez-Cabré E, Rodríguez M. Blink rate and incomplete blinks in six different controlled hard-copy and electronic reading conditions. Invest Ophthalmol Vis Sci. 2015;56:6679-85.
10. *Uchino* M, Yokoi N, Uchino Y, Dogru M, Kawashima M, Komuro A, et al. The Osaka study shows the prevalence of dry eye disease and its risk factors in visual display terminal users. Am J Ophthalmol. 2013;156:759-66.
11. Caffery B, Srinivasan S, Reaume CJ, Fischer A, Cappadocia D, Siffel C, et al. Prevalence of dry eye disease in Ontario, Canada: a population-based survey. Ocul Surf. 2019;17:526-31.
12. Qian L, Wei W. Identified risk factors for dry eye syndrome: a systematic review and meta-analysis. PLOS ONE.2022;17:e0271267 https://doi.org/10.1371/journal.pone.0271267
13. YANG I, SACHO IB, LOPES GA, VIZOTTO MP, DI GREGORIO B, REBELLO PA, ET AL. DRY EYE PREVALENCE AND MAIN RISK FACTORS AMONG BRAZILIAN MEDICAL STUDENTS. INVEST OPHTHALMOL VIS SCI. 2019;60:2740
14. Matossian C, McDonald M, Donaldson KE, Nichols KK, MacIver S, Gupta PK. Dry eye disease: consideration for women's health. J Womens Health (Larchmt). 2019;28:502-14.
15. Farrand KF, Fridman M, Stillman IÖ, Schaumberg DA. Prevalence of diagnosed dry eye disease in the United States among adults aged 18 years and older. Am J Ophthalmol. 2017;182:90-8.
16. Almujalli AA, Almatrafi AA, Aldael AA, Aljudi TW, Abdulhalim BE. The prevalence and risk factors for symptomatic dry eye in adults in Riyadh, Saudi Arabia. Open J Ophthalmol. 2021;15:277-82
17. Alshamrani AA, Almousa AS, Almulhim AA, Alafaleq AA, Alosaimi MB, Alqahtani AM, et al. Prevalence and risk factors of dry eye symptoms in a Saudi Arabian population. Middle East African J Ophthalmol. 2017;24:67-73.
18. Bakkar MM, Shihadeh WA, Haddad MF, Khader YS. Epidemiology of symptoms of dry eye disease (DED) in Jordan: a cross-sectional non-clinical population-based study. Cont Lens Anterior Eye. 2016;39:197-202.
19. Lin F, Cai Y, Fei X, Wang Y, Zhou M, Liu Y. Prevalence of dry eye disease among Chinese high school students during the COVID-19 outbreak. BMC Ophthalmol. 2022;22:1-8.
20. GArG A, BhArGAv S, ArOrA T, GArG A. Prevalence and risk factors of dry eye disease at a tertiary care centre in Haryana, India: a cross-sectional study J Clin Diagn Res. 2022;16.
21. Garza-León M, López-Chavez E, De La Parra-Colín P. Prevalence of ocular surface disease symptoms in high school students in Monterrey, Mexico. J Pediatr Ophthalmol Strabismus. 2021;58:287-91.
22. Matossian C, McDonald M, Donaldson KE, Nichols KK, MacIver S, Gupta PK. Dry Eye Disease: Consideration for Women's Health. J Women's Health (2002). 2019;28:502-14.
23. Sriprasert I, Warren DW, Mircheff AK, Stanczyk FZ. Dry eye in postmenopausal women: a hormonal disorder. Menopause (New York, NY). 2016;23:343-51.
24. Craig JP, Nelson JD, Azar DT, Belmonte C, Bron AJ, Chauhan SK, et al. TFOS DEWS II report executive summary. Ocul Surf. 2017;15:802-12.
25. Hu JW, Zhu XP, Pan SY, Yang H, Xiao XH. Prevalence and risk factors of dry eye disease in young and middle-aged office employee: a Xi'an Study. Int J Ophthalmol. 2021;14:567-73.
26. Greenhalgh T, Schmid MB, Czypionka T, et al. Face masks for the public during the COVID-19 crisis. Br Med J 2020;369: m1435. Published 2020 Apr 9.
27. Krolo I. Mask-associated dry eye during COVID-19 pandemic - how face masks contribute to dry eye disease symptoms. Med Arch. 2021;75:144-8.
28. Moshirfar M, West WB, Jr, Marx DP. Face mask-associated ocular irritation and dryness. Ophthalmol Ther. 2020;9:397-400.
29. Dikmetaş Ö, Tellioğlu HT, Öztüran İ, Kocabeyoğlu S, Çankaya AB, İrkeç M. The effect of mask use on the ocular surface during the COVID-19 pandemic. Turk J Ophthalmol. 2023;53:74-8.
30. Versura P, Giannaccare G, Campos EC. Sex-steroid imbalance in females and dry eye. Curr Eye Res. 2015;40:162-75.
31. NG A, EVANS K, NORTH RV, JONES L, PURSLOW C. IMPACT OF EYE COSMETICS ON THE EYE, ADNEXA, AND OCULAR SURFACE. EYE CONTACT LENS. 2016;42:211-20.

Investigative Ophthalmology & Visual Science

32. Bayhan HA, Bayhan SA, Muhafiz E, Gürdal C. Evaluation of the dry eye parameters and tear osmolarity in computer users. Turkiye Klinikleri J Ophthalmol

33. Uchino M, Yokoi N, Uchino Y, Dogru M, Kawashima M, Komuro A, et al. Prevalence of dry eye disease and its risk factors in visual display terminal users: the Osaka study. Am J Ophthalmol. 2013;156:759-66.