Clinical Ophthalmology

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ORIGINAL RESEARCH

Computer Vision Syndrome in Undergraduate and Medical Students During the COVID-19 Pandemic

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Purpose: The purpose of this study was to evaluate Computer Vision Syndrome (CVS) in undergraduate and medical students since transitioning to online learning during the COVID-19 pandemic.

Patients and Methods: This was a cross-sectional single center survey-based study using a validated CVS questionnaire (CVS-Q). The survey was distributed to 20,080 undergraduate students and 680 medical students at the University of Illinois at Chicago. The primary outcome measures were prevalence of CVS (based on CVS severity score of 6 or more), frequency of CVS and intensity of CVS symptoms.

Results: The survey was completed by 2300 undergraduate students (11.4% response rate) and 154 medical students (22.6% response rate). The prevalence of CVS was 77.1% in undergraduate students and 69.1% in medical students. CVS-Q severity scores were highest for headaches and eye dryness, with over half of students reporting worsening of symptoms since March 2020. Increased time spent on online learning (undergraduate: P <0.001, medical: P = 0.018), blue light glasses usage (undergraduate: P <0.001, medical: P = 0.0015), and increased number of device usage were associated with higher CVS severity scores (undergraduate: P <0.001, medical: P = 0.0032).

Conclusion: CVS among undergraduate and medical students has increased since the start of the COVID-19 pandemic. More focus should be placed on the management of CVS for students in higher education. Physicians should be cognizant of the consequences of online learning and be proactive about providing advice regarding preventative measures.

Keywords: digital eye strain, screen time

Introduction

Computer vision system (CVS), also known as digital eye strain (DES), is a common repetitive eye strain disorder with ocular symptoms including eyestrain, tired eyes, irritation, and blurred vision. CVS can also present with non-ocular symptoms, such as headache, neck, and shoulder pain. Risk factors include uncorrected refractive error, close working distance, small font size, and excessive exposure to intense light.[1–4] Management of CVS is preventative, including strategies such as appropriate correction of refractive errors, management of vergence anomalies, and blink training to maintain normal blinding patterns.[1,3,4]

Prior to the COVID-19 Pandemic lockdown in March 2020, many studies looked at the prevalence of CVS within different populations, ranging from the general population to office workers.[5–16] The 2016 Digital Eye Strain report compiled survey responses from over 10,000 US adults found an overall self-reported CVS symptom prevalence of 65%.[6] Portello et al surveyed a cohort of 520 office workers in New York City and found that nearly 40% reported the symptom of "tired eyes" and 30% reported the symptoms of "dry eyes" and "eyestrain" occurring "at least half of the time" during a given week.[7] In 2016, Tauste et al found that the prevalence of CVS was 53% among 426 civil servants in Spain through the Computer Vision Syndrome Questionnaire (CVS-Q).[8]

Received: 1 February 2023
Accepted: 10 March 2023
Published: 10 April 2023

Despite the interest in CVS in office environments, few studies have examined CVS prevalence in higher education, all conducted outside of the US.[9,10,17–22] Logaraj et al, in a cross-sectional study of medical and engineering college students attending an university in Chennai, India, found the prevalence of CVS to be 81.9% among engineering students and 78.6% among medical students.[9] A 2018 study from Kist Medical College in Lalitpur, India, found that 74% of students complained of one or more CVS manifestations.[10] Among students in the Faculty of Medical Sciences in a university in Jamaica, the most commonly reported CVS symptoms were neck pain (75.1%), eye strain (67%), and shoulder pain (65.5%).[23] A paper published just prior to the onset of the COVID-19 pandemic found that CVS was common among undergraduate medical students in Saudi Arabia, with 95% of students reporting at least one symptom during their studies.[24]

Since the start of the COVID-19 pandemic, many articles, both general media and scientific, have been published discussing the rise of CVS during the pandemic.[25–29] These articles highlighted the sharp increase in digital device use since the start of the pandemic and the associated decline of ocular health across age groups.[29] Within student populations, the sharp increase is contributed by the fact that educational institutions have adopted and transitioned to web-based learning to overcome barriers to physical meetings and in-person lectures.[30,31] The sudden increase in online learning may have significant ocular and extraocular effects.[32–34] A study in China that surveyed students from grades 1–12 found that during the COVID-19 pandemic, 75% of students reported CVS symptoms.[35] Another study found that when compared to students who continued with classroom lectures, students that took online lectures were more likely to report CVS symptoms.[36] Despite the growing interest in CVS, the literature regarding the CVS symptoms in online learners at higher education institutions during the COVID-19 pandemic remains scarce. Furthermore, with many educational institutions largely using web-based platforms, the prevention of CVS becomes challenging. Most recently, Sivaraman et al, in a letter to the editor, discussed the need to use evidence-based approaches to prevent and decrease CVS symptoms.[37]

This survey study was conducted to evaluate and quantify the prevalence of CVS in undergraduate and medical students since the beginning of the COVID-19 pandemic in March 2020. The secondary goals of this survey study included quantification of symptom severity and any associated risk factors.

Materials and Methods

This was a single-center observational survey study conducted at the University of Illinois at Chicago (UIC). It was approved by the UIC Institutional Review Board. Participants included all UIC undergraduate and medical students. The anonymized survey was administered online (www.qualtrics.com). Electronic informed consent was obtained from all participants. The survey consisted of 15 questions: three demographics questions, eight questions about time spent online and methods of online education, and questions from the previously validated CVS survey by Segui et al (38) Students were asked about their current and previous CVS symptoms. Survey questions regarding the demographics and time spent online were content screened by 2 ophthalmologists (KJ and DE). The survey tool may be viewed in the e-Appendix.

The survey was distributed to over 20,000 undergraduate students and 682 medical students via email in January of 2021. Calculation of CVS syndrome prevalence and severity score was based on previously validated analysis using the CVS-Q by Segui et al (38) CVS severity score was calculated by multiplying frequency by intensity of symptoms reported. CVS was defined as a severity score of 6 or more. The severity and frequency of each CVS syndrome was evaluated and analyzed separately. Descriptive statistics are reported with median (± inter quartile range, IQR) for continuous variables, and percentages for categorical variables. Difference in CVS severity scores was compared between various demographic variables. The Wilcoxon rank-sum or Kruskal Wallis test was used to compare CVS severity by dichotomous or categorical variables. A significance level of $p \leq 0.05$ was used for all statistical analysis. All analyses were conducted using R (R Core Team (2019). R: URL https://www.R-project.org/).

Results

The survey was completed by 2300 undergraduate students (11.4% response rate) and 154 medical students (22.6% response rate). The demographic results of the survey participants can be found in Table 1 and the summary of responses to the CVS survey are found in Table 2.

Table 1 Demographic Breakdown of Students

	n (%)	CVS Score Summary Median (IQR) [Min, Max]
Undergraduate year of study		
1st Year	604 (26.3)	9 (7) [0,26]
2nd Year	557 (24.2)	9 (8) [0,27]
3rd Year	601 (26.1)	10 (8) [0,32]
4th Year	446 (19.4)	10 (8) [0,32]
5th Year	80 (3.5)	9 (7) [0,27]
6th Year	12 (0.5)	9 (8) [0,19]
Undergraduate field of study		
Applied Health Sciences	133 (5.8)	10 (9) [0,25]
Architecture, Design, Arts	173 (7.5)	10 (7.75) [0,31]
Business Administration	257 (11.2)	10 (10) [0,32]
Education	72 (3.1)	10 (7) [1,27]
Liberal Arts and Sciences	1052 (45.7)	10 (7.25) [0,32]
Medicine (Non-MD Students)	22 (1.0)	12 (8.5) [0,20]
Nursing	72 (3.1)	11 (7) [0,24]
Other	471 (20.5)	8 (8) [0,24]
Pharmacy	9 (0.4)	10.5 (6.25) [7,19]
Public Health	25 (1.1)	10 (5) [3,18]
Urban Planning and Public Affairs	14 (0.6)	10 (4) [4,21]
Medical Student Year of Study		
1st Year	69 (44.8)	8 (6) [2,22]
2nd Year	30 (19.5)	7.5 (6.75) [1,16]
3rd Year	28 (18.2)	7.5 (7) [2,18]
4th Year	26 (16.9)	6 (4.5) [0,12]
6th Year (MD/PhD)	1 (0.6)	8 (0) [8,8]

Table 2 The Characteristics of Online Learning of Student Responders

	Overall	Undergrads (n=2300)	Medical Students (n=154)
Time attending virtual classes (hours/day)			
2–4	1469 (59.9)	1391 (60.5)	78 (51.3)
4–8	572 (23.3)	542 (23.6)	30 (19.7)
< 2	332 (13.6)	289 (12.5)	43 (28.3)
> 8	78 (3.2)	77 (3.4)	1 (0.7)

(Continued)

Table 2 (Continued).

	Overall	Undergrads (n=2300)	Medical Students (n=154)
Time spent on online learning (hours/day)			
2–4	703 (28.7)	672 (29.3)	31 (20.4)
4–8	1074 (43.9)	1005 (43.7)	69 (45.4)
< 2	135 (5.5)	121 (5.3)	14 (9.2)
> 8	536 (21.9)	498 (21.7)	38 (25)
Time spent on online learning since March 2020			
100% more	1061 (43.3)	986 (42.9)	75 (49.3)
25% more	196 (8)	176 (7.7)	20 (13.2)
50% more	944 (38.6)	901 (39.2)	43 (28.3)
About the same	169 (6.9)	160 (7.0)	9 (5.9)
Less	79 (3.2)	74 (3.2)	5 (3.3)
Primary device			
Desktop	273 (11.1)	260 (11.3)	13 (8.6)
Laptop	2104 (86.0)	1969 (85.8)	135 (88.8)
Phone	24 (1.0)	35 (1.5)	1 (0.7)
Tablet	36 (1.5)	22 (1.0)	2 (1.3)
Other	11 (0.4)	10 (0.4)	1 (0.6)
Maximum number of devices			
1–2	1808 (73.8)	1722 (75.0)	86 (56.6)
3–4	604 (24.7)	540 (23.5)	64 (42.1)
>5	37 (1.5)	35 (1.5)	2 (1.3)
Wear glasses or contacts			
Yes, contacts	293 (12.0)	269 (11.7)	24 (15.8)
Yes, glasses	1217 (49.7)	1139 (49.6)	78 (51.3)
Neither	938 (38.3)	888 (38.7)	50 (32.9)
Blue light glasses			
No	1722 (70.4)	1617 (70.5)	105 (70)
Yes	723 (29.6)	678 (29.5)	45 (30)
Anti-glare screen			
No	2186 (89.3)	2046 (89.1)	140 (92.1)
Yes	261 (10.7)	249 (10.9)	12 (7.9)

Both undergraduate and medical students reported spending more time on online learning since March 2020 (89.9%), with 43.3% stating that they doubled the amount of time on online learning. Almost half (43.9%) spent 4–8 hours per day on online learning and 21.9% reported more than 8 hours per day. Within the medical student population, 25% of students reported spending more than 8 hours per day on online learning. Most students (73.8%) used 1–2 devices for studying, with 86.0% of students primarily using a laptop. Twelve percent of students primarily wore contact lenses during their studying hours and 49.7% of students primarily wore glasses during their studying hours. Blue light glasses were worn by 29.6% of students, and only 10.7% of students used an anti-glare screen.

The prevalence of CVS was 77.1% in undergraduate students and 69.1% in medical students. Headache (77.9%), eye burning (70.5%), eye itching (68.9%), and dryness (68.5%) were the most reported symptoms by undergraduate students. Similarly, headache (78.3%) and dryness (77.6%) were the most reported symptoms by medical students; most students reported these symptoms as moderate on the severity scale.

In the undergraduate student population, of those who reported headache symptoms, 33.5% of students did not have these symptoms before the COVID-19 pandemic. Within those students who did have headaches prior to March 2020, 44.9% reported an increase in frequency and/or intensity (Figure 1). Additionally, amongst the students who reported headache symptoms, 33.2% of students reported it to be severe. Similarly, 33.0% of medical students who reported headache symptoms did not have headache symptoms prior to March 2020, and of those who did have symptoms prior, 48% of students reported an increase in frequency and/or intensity (Figure 2).

Among undergraduate students who reported eye burning symptoms, 58.2% did not have these symptoms before March 2020. More than half (53.5%) of students who did have eye burning prior reported increased symptom frequency and/or intensity (Figure 1). Of the undergraduate students who reported itching symptoms, 54.6% did not have eye itching before March 2020, and of those who did have symptoms prior, 37.9% reported an increase in frequency/intensity. Eye dryness prior to March 2020 was reported by 58.7% of undergraduates and 38.6% of medical students, with 54.4% and 50%, respectively, reporting an increase in frequency and/or intensity of symptoms since the start of the pandemic.

There were significant differences in CVS scores between different undergraduate programs of study, specifically between students in "Other" programs and those in Architecture, Design, Arts program, those in "Other" programs and those in Education program, and those in "Other" programs and those in Health programs ($P = 0.001$) (Table 1). "Other" programs included College of Engineering, Honors College, and Council on Teacher Education and Health programs include Applied Health Sciences, Medicine (undergraduate program), Nursing, Pharmacy, and Public Health. For both undergraduate and medical student populations, there was no significant relationship between year of study and CVS scores (undergraduate: $P = 0.81$, medical: $P = 0.24$).

For undergraduate students, more time spent on attending virtual classes and online learning was associated with higher CVS severity scores ($P < 0.001$) (Table 3). For medical students, more time spent on online learning (but not on attending virtual

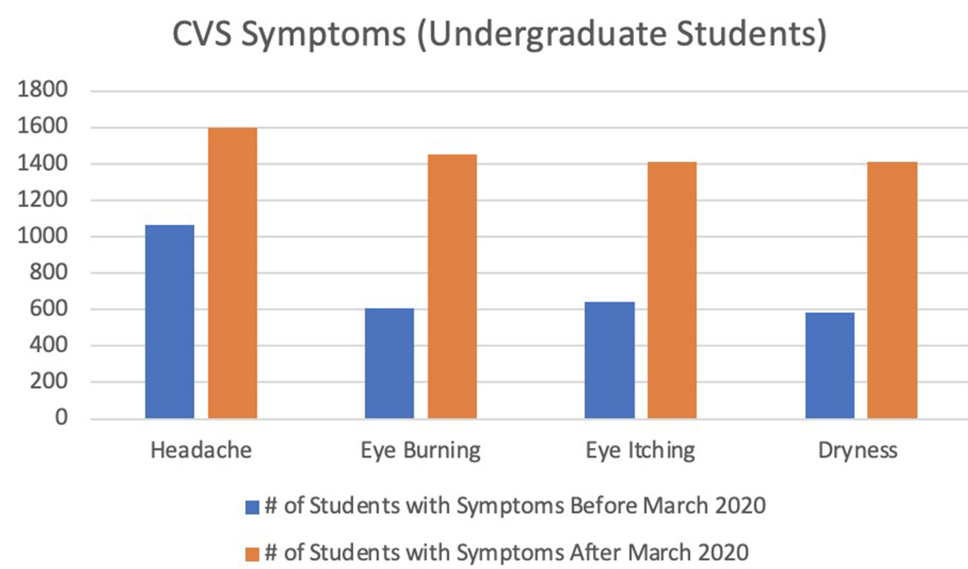

Figure 1 Comparison of number of undergraduate students with individual CVS symptoms before and after March 2020.

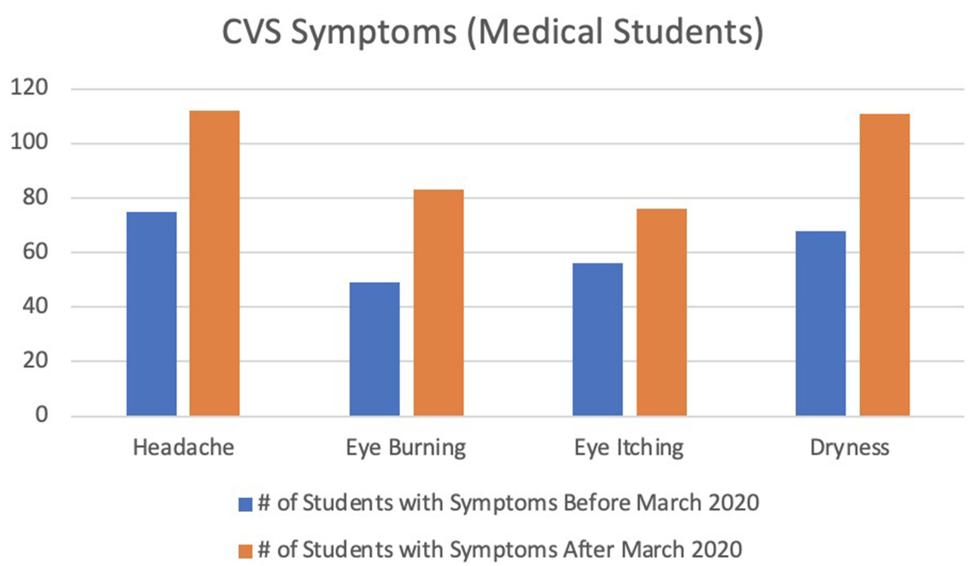

Figure 2 Comparison of number of medical students with individual CVS symptoms before and after March 2020.

classes) was associated with higher CVS severity scores (P = 0.018). For undergraduate students, glasses and contact lens wear were associated with higher CVS severity scores (P = 0.003). The association was not statistically significant for medical students. Undergraduate students who used laptops as their primary device had significantly higher CVS scores than those who used desktops (P <0.001); there was no relationship between the primary device used and CVS scores for medical students. For both undergraduate and medical students, blue light glasses usage was associated with higher CVS severity scores (undergraduate: P <0.001, medical: P = 0.0015). Additionally, students who reported using 3–4 devices had higher CVS scores than those using 1–2 devices (P <0.001). Among the other factors we looked at, including anti-glare screen usage, none were identified to have associations with CVS (Table 2).

Table 3 CVS Associations Associated with Different Variables

	Undergraduate Students		Medical Students	
	CVS Severity Score Median (IQR) [Min, Max]	**p-value**	**CVS Severity Score Median (IQR) [Min, Max]**	**p-value**
Time attending virtual classes (hours/day)				
2–4	9 (7) [0,32]	<0.001	7 (6) [2,18]	0.32
4–8	11 (8) [0,32]		9 (8) [1,22]	
< 2	7 (8) [0,25]		7 (6) [0,17]	
> 8	14 (9.25) [1,27]		6 (0) [6,6]	
Time spent on online learning (hours/day)				
2–4	8 (7) [0,32]	<0.001	5.5 (5.75) [2,17]	0.011
4–8	10 (8) [0,25]		7 (7) [1,18]	
< 2	8 (7) [0,28]		7 (5) [0,11]	
> 8	12 (8) [0,32]		9 (6) [2,22]	

(*Continued*)

Table 3 (Continued).

	Undergraduate Students		Medical Students	
	CVS Severity Score Median (IQR) [Min, Max]	**p-value**	**CVS Severity Score Median (IQR) [Min, Max]**	**p-value**
Time spent on online learning since March 2020				
100% more	11 (8) [0,32]	<0.001	9 (6) [0,22]	0.018
25% more	8 (6.5) [0,22]		7 (3) [2,12]	
50% more	9 (7) [0,28]		7 (7) [2,18]	
About the same	6 (8) [0,21]		5.5 (1.25) [3,7]	
Less	9 (7.5) [0,23]		4 (2) [3,7]	
Primary device				
Desktop	7 (8) [0,24]	<0.001	8.5 (4.5) [4,16]	0.060
Laptop	10 (8) [0,32]		7 (7) [0,22]	
Other	8 (7.5) [0,19]		14.5 (7.25) [8,22]	
Maximum number of devices				
1–2	9 (7) [0,32]	<0.001	7 (5) [0,16]	0.0032
3–4	11 (9) [0,32]		9 (6) [2,22]	
>5	12 (13) [0,20]		5 (0) [5,5]	
Wear glasses or contacts				
Yes, contacts	10 (7) [0,32]	0.003	9.5 (6.75) [2,18]	0.19
Yes, glasses	10 (8) [0,32]		8 (6) [2,22]	
Neither	9 (7.75) [0,31]		7 (5) [0,16]	
Blue light glasses				
No	9 (8) [0,29]	<0.001	7 (5.5) [0,17]	0.0015
Yes	11 (8) [0,32]		9.5 (5.75) [3,22]	
Anti-glare screen				
No	10 (8) [0,32]	0.95	7 (6.5) [0,22]	0.075
Yes	9 (9) [0,32]		9 (5.5) [4,18]	

Discussion

This study describes the findings of a computer vision syndrome (CVS) survey conducted in early 2021 in undergraduate and medical students at a large academic institution in the United States. We found that 77.1% of undergraduate students and 69.1% of medical students met the criteria for CVS and that CVS among undergraduate and medical students has increased since the COVID-19 pandemic and transition to online learning. We used a previously validated survey and CVS calculation method by Segui et al to conduct the study.[38] The study was completed by 2300 undergraduate students and 154 medical students, with a response rate of 11.4% and 22.6%, respectively. Our undergraduate responses came from students from various fields of study. Both populations reported an increase in online learning, with almost half of responders sharing that they had doubled the amount of time they spend on online learning. Notably, our study found that greater time spent on online learning was associated with higher CVS severity scores in both undergraduate and medical students. This is consistent with other studies that have examined the relationship between duration of device usage and CVS symptoms in the pre-Covid period.[9,39]

We are unaware of previous reports examining the prevalence of CVS within students attending higher education in the US and could find no reference to it in a computerized search of PubMed in April 2022. The increase in CVS symptoms is consistent with other studies examining the impact of the COVID-19 pandemic on ocular health.[40] Bahkir et al conducted a general population study in India and found a drastic increase in digital device usage since the start of the pandemic and a corresponding deterioration of eye health.[41] More recently, Garcia-Ayuso et al found that university students in Spain reported increased prevalence of dry eye symptoms after transitioning to a hybrid learning environment.[42]

Notably, there were similarities between the most reported symptoms and the reported increase in frequency and/or intensity between undergraduate and medical students. For example, in our study, headache was the most common CVS symptom reported in both undergraduate and medical students, 77.9% and 78.3% respectively. Of students who previously experienced headaches, 44.9% of undergraduates and 48% of medical students reported an increase in frequency and/or intensity. This is consistent with the findings reported by Altalhi et al who found that headache was the most common CVS complaint, with 68% of health sciences students reporting the symptom.[39] It is important to note that many published studies examining the prevalence of CVS within student populations did not use specific criteria for defining CVS (unlike our study); instead, previous studies report the prevalence of individual CVS symptoms.

Interestingly, our study found that in both undergraduate and medical students, blue light glasses usage was associated with significantly higher CVS severity scores. While there are multiple potential explanations for this observation, the most plausible interpretation is that students with existing CVS symptoms were more likely to try blue light glasses for symptomatic relief. It is unlikely that blue light glasses themselves were causing more severe CVS symptoms. A 2017 systemic review found little evidence supporting the use of blue-blocking filters to alleviate CVS symptoms, and more recently, Rosenfield et al found no difference in CVS symptoms between patients wearing lenses with a blue-blocking filter and those with a clear CR 39 lens.[43,44] Additionally, within the undergraduate population, there was a significant difference in CVS severity scores between those with contacts and those without contacts, which is consistent with a 2016 study that surveyed office workers and found that contact lens users reported an increased prevalence of CVS symptoms.[8] In both student populations, students who used 3–4 devices reported higher CVS severity scores than those who used 1–2 devices. The higher CVS scores associated with higher device usage could be related to an increase in total screen time by these multi-device users resulting in CVS, or users using multiple devices to see if a particular device ameliorated their CVS symptoms. The difference in CVS scores in the undergraduate population suggests that the field of study may contribute to CVS. This is likely due to differences in required screen time between programs, whether that be mandatory class time or time spent on online assignments and studying. A previous study comparing engineering and medical students in India found that the prevalence of CVS was higher in engineering students than medical students and that a greater proportion of engineering students reported higher daily computer usage times.[9]

There were several limitations to our study. While no single program of study was associated with higher CVS severity scores, students that reported “Other” as their field of study had overall lower scores. However, “Other” includes a variety of study fields, so we cannot identify which specific fields were associated with lower CVS severity scores. Another limitation is the absence of a pre-March 2020 CVS survey to serve as a baseline for our survey. It is possible that there might be some bias in the reporting since the survey was conducted during the pandemic. However, our subjective responses from students indicate that CVS symptoms have worsened since March 2020. The overall response rate to the survey was modest: 11.4% in undergraduate students and 22.6% in medical students. For university students, survey engagement rates might vary from 14–70% while medical student response rates to surveys have been reported to be around 30%.[45,46] The number of surveys that were administered to students in higher education during our survey period and “COVID-19 fatigue” likely contributed to the lower response rates. Of note, there is no single minimum for acceptable response rates for surveys. Templeton et al concluded that if nonresponse effects are documented and understood, a low response rate does not need to affect the validity of the data.[47,48] Given that Fosnacht et al found that as long as the sampling frame included at least 500 students, low survey response rates (5–10%) within college students still provided reliable responses, our data likely definitively represents the undergraduate and medical student communities.[49] Additionally, this study's quantity of responses is greater than existing studies that looked at CVS symptoms in student populations. However, we were unable to compare response rates with other studies as they did not include the rates in their publications.

Conclusion

Overall, this study shares insight into the prevalence of CVS symptoms in undergraduate students and medical students in the United States since the start of the COVID-19 pandemic. While the transition to online learning was critical, healthcare stakeholders should be aware of its impact on student health. With online learning potentially becoming a more permanent fixture in higher education, educators and administrators should be aware of and be proactive about potential ocular health side effects. More focus should be placed on developing sustainable methods to decrease CVS within student populations, such as optimizing screen interventions for users.[50] Future studies can also look into the relationship between CVS symptoms and field of study to further identify vulnerable student populations. The long-term consequences of CVS are still relatively unclear, but ophthalmologists should be aware of the pandemic's secondary collateral eye health impacts in the student population.

Disclosure

The authors have presented this abstract at the American Ophthalmological Society 2022. The authors report no conflicts of interest in this work.

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