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Assessing the Impact of Prolonged Screen Time on Ophthalmic Health among Students: A Post-COVID-19 Study in Pakistan

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ABSTRACT

Human beings heavily rely on the sense of sight, as sight mainly controls approximately 80% of our perception. During the COVID-19 pandemic, students had to take their online classes by using different electronic devices. By not following the proper instructions to use these devices, primary students faced eyesight issues during the COVID-19 pandemic. Low Vision is a commonly diagnosed issue in ophthalmology in Pakistan. Therefore, the current study is a survey-based research. For this purpose, a population of 100 primary students was gathered who took online classes during the pandemic and developed eyesight issues after their online classes. Based on statistical analysis, the logistic regression model was used to analyze the eyesight issues among the primary students considering several variables including gender, age, distance with devices, duration of using the devices, and analyzing previous eyesight issues. The findings indicated that male students have a more chance of developing eyesight issues than female students. Hence, it was deduced that female students who used their devices from a distance of more than 16 inches for less than 3 hours had the least possibility of developing any eyesight issues.

Keywords: COVID-19, eyesight issues, ophthalmology, logistic regression

1. INTRODUCTION

Throughout history, notable pandemics such as AIDS, dengue, cholera, plague, influenza, smallpox, and severe acute respiratory syndrome have had far-reaching consequences, affecting not only the healthcare system but also the economy, society, and security. Several key factors contribute to the facilitation of a pandemic, including its global reach, novelty, severity,

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reduced immunity, high infection rates, and other related aspects [1].

Prior to early December 2019, numerous symptoms resembling pneumonia were documented in Wuhan, located in Hubei province, China [2]. These symptoms occurred because of the re-emergence of the coronavirus in the form of SARS-COV 2 [3]. In Pakistan, authorities reported the first two COVID-19 cases in March 2020 in Islamabad [4]. The lockdown was imposed countrywide and people were forced to isolate themselves in their houses. The traditional mode of education was shifted to an online education medium, which opened new gateways and new opportunities for students to learn this new medium of education [5]. Online education brought many challenges, which include a lack of proper infrastructure for educational setup, technical issues like internet lagging leading to voice and video disruption, and a lack of face-to-face interaction among teachers. Primary-level of students were dependent on their parents for their academic work and the online education system was new to their parents. Thereby, students or teachers developed several health conditions that were also connected to the online education system including eyestrain, cervical pain, lumbago, vertigo, headaches, psychological issues, lack of physical activity, and eyesight issues.

The eye is the most delicate and sensitive organ of the human body. It is susceptible to any damage that could be chemical, physical, environmental, and others, which may affect its ability to envisage leading numerous eye-related issues. The structure of the eye mainly comprises the conjunctiva, sclera, iris, pupil, lens, and retina. The conjunctiva is a mucous membrane made up of non-keratinizing squamous epithelium containing goblet cells, langerhans cells, and dendritic melanocytes [6]. It protects and lubricates the eye by producing mucous and tears [7]. As light strikes the retina, several chemical reactions take place within different cell layers such as rods and cones. These chemical reactions in the form of electrical signals disseminate through nerve cells into the second cranial nerve [8]. Several abnormalities associated with the eye include ageing, increased exposure to unshielded screens, trauma, infections, and family history. The main issues that could occur due to prolonged exposure to screens are eye itching, irritation, burning, redness, drying, and fatigue. Long-sightedness (hypermetropia) and shortsightedness (myopia), which are the most common abnormalities in growing ages. Hypermetropia occurs when the eyeball is too short so the focus point is behind the retina at the back of the

eye. If this condition occurs in students, a squint may be noticed, for instance, one eye turning inward. On the other hand, myopia occurs when a person is unable to see only nearby objects.This condition occurs when the length of the eye is excessive, causing the light to converge in front of the retina located at the back of the eye. Myopia is a serious condition because if a child becomes myopic before nine years old, there are chances that he or she may develop a high level of myopia in the future, which makes them prone to glaucoma, retinal detachments, and myopic retinal degeneration. There are also chances of complete loss of eyesight for the high-level myopic person [9]. Dry eye is an eye condition that leads to ocular tenderness. It is characterized by a disruption in the tear film, resulting in the drying of tears. This condition is commonly associated with decreased intervals between blinking [10, 11]. Continuous use of screens can cause eye fatigue and soreness, which contributes to the eye injury and diseases like refractive error, myopia, cataract, and glaucoma [12]. Recently, eye abnormalities are associated with increased exposure time to screens among all age groups. In the last couple of years, as the COVID-19 lockdown prompted a global shift towards online education, numerous reports in the literature have highlighted the prevalence of eyesight problems. During the COVID-19 pandemic lockdown in the past two years, the traditional education system shifted to online educational medium. Reportedly, many eyesight cases were noted during this particular time of the COVID-19 pandemic.

However, in Pakistan, such issues remained unnoticed due to the dearth concerns, such as financial issues and regular checkup. People in this crucial time avoided visiting hospitals because of fear of getting COVID from the hospitals of infected patients. According to WHO, 2.2 billion people around the world suffered from eye conditions [13]. *Bahkir* reported that the increase in the usage of digital devices during COVID-19 led to an adverse effect on ocular health in all age groups. Therefore, 90.42% of the respondents reportedly experienced eye abnormalities due to the excessive usage of digital devices. In their study, they identified a high incidence of dry eye and headache in females. A percentage of 43.5% of people experienced headaches, 29% had eye pain, 23.8% had heavy eyelids, and 74.2% had sleep disturbances [14]. *Balsam Alabdulkader* through a self-reported questionnaire estimated that the prolonged use of digital devices increased during the COVID-19 pandemic and reported that 78% of students faced digital eyestrains [15]. *Bengi Demirayak* elaborated increase

in digital device use during COVID-19 exacerbated the digital eyestrain problem in students. Hence, 52.2% of students experienced headaches as the most common symptom [16]. *Abdullah Altalhi* conducted an electronic self-administered survey on KSAUHS students in Saudi Arabia of Computer Vision Syndrome (CVS). It was reported that CVS symptoms were reportedly higher in female students who used to wear spectacles and observed glare on the screen. Reportedly, the most common symptoms noticed among students were headache (68%), feeling of affected eyesight (65%), eye itchiness (63%), burning sensation (62%), excessive blinking (40%), and difficulty moving eyelids (9%) [17].

In China, more than 180 million of primary and secondary school students were circumscribed to their homes. It was observed that students were less physically active with longer screen time and irregular diet resulted in cardiorespiratory weaknesses [18]. Homeschooling is a unique and alternative format of education. According to the student demographic questionnaire, 17.6% of students were identified as having behavioural and emotional effects. However, low-grade students were more at risk with 19.3% as compared to high-grade students having 13.7% effects [19]. According to the Indian Journal of Ophthalmology, a survey conducted among 217 individuals showed the frequency of digital eyestrain to be 50.23%. Common manifestations observed were itching in the eyes and headache (53.9%). This survey-based research highlighted the prevalence of digital eyestrain causing ocular health issues due to increased usage of digital devices [20]. Increased usage of digital devices among students for online sessions showed the progression of myopia in individuals. The percentage of myopic individuals reached up to 10.40% in Chongqing, China [21]. Researchers used the chi-square test for analyzing the immense use of computers by university students and it was identified that burning eyes and tired eyes were the common symptoms reported among students [22]. Computer vision syndrome was reported in 75% of visual display terminal workers as compared to other workers [23].

Ugam Usgaonkar through his e-survey-based research estimated that most of the respondents were involved in more than two digital activities on more than two digital devices. The symptoms observed were watery eyes, headache, dry eyes, shoulder pain, pain behind the eye, and back pain. The increase in ocular symptoms was due to an increase in time spent on digital devices [24]. *Richa Gupta* elaborated on the adverse effect of e-learning on

the eye health of school students during COVID-19 through survey-based research. A percentage of 92.8% of students reportedly had eyestrain symptoms. The most common symptoms were eye redness, which was 69.1% and heaviness of the eyelid, which was 79.7% [25]. *Pratyusha Ganne* analyzed the digital eyestrain problem due to the increase in digital device usage during COVID-19. The prevalence of eyestrain was found to be higher in students, which were attending online classes. The prime factors, which were involved, were pre-existing eye disease, greater screen time, screen distance, and using the screen in the dark [26].

In this paper, a survey-based research regarding the ophthalmic health of primary school students was conducted as a result of attending online classes through different digital devices during COVID-19. The current study was designed to analyze the impact of online education on their eyesight is qualitative, based on survey of 100 primary students, 59 female, and 41 male students conducted for the age group 4 to 12 years. It was also observed that some students were already facing eye abnormalities, which may include eyestrain, red eyes, night blindness, uveitis, presbyopia, floaters, dry eyes, cataracts, retinal disorders, corneal diseases, and others. For this purpose, Logistic regression analysis would help to estimate the probability of the eyesight issues of the primary students after online education. This dichotomous variable would be used as a dependent variable, which depends on gender, age, the distance of the device with the eyes, duration of the user device, and already facing any eye health issues.

2. METHODOLOGY

2.1. Statistical Model and Analysis

The relationship between a dichotomous dependent variable and one or more independent categorical variables was illustrated by binary logistic regression analysis. This model provides odds, odds ratio, and probability statistics, which can be highly useful in properly expressing the research goal [27]. Generally, this model is used while discussing a dependent variable, which is binary, dichotomous, or alternative, rather than continuous variables [28, 29]. There are other statistical models, which can be applied in previous literature related to statistical convergence [30, 31].

The IBM SPSS version 25.0 software was used to find out the relationship between eyesight issues with the explanatory variables of gender, age, the distance of the device with the eyes, duration of using the

device, and people who were already facing any eye abnormalities. In the study population 100 primary students who have taken online classes during the pandemic, 59 were female and 41 were male students with different age groups ranging from 4-12 years. The device distance could be less or greater than 16 inches. The duration of using devices for online education was noticeably more or less than 3 hours. Another significant aspect to consider is whether the student had experienced any eye-related issues prior to the onset of the COVID-19 pandemic. After executing the logistic regression in IBM SPSS, some information was obtained, which helped to estimate the impact of the devices used for online education on primary students' eyes.

2.2. Model Diagnosis

Model diagnosis shows the complete analysis of the model execution. Table 1 provides a complete indication of how well the model executes. This is also termed as a "Goodness of fit test". It is utilized to decide the rate of an exact number of expectations in total predictions. The significant value in the Omnibus test is less than 0.05, which reflects that the model is significant. The chi-square statistic is 19.224 with 5 degrees of freedom. Therefore, the overall model is statistically significant, χ^2 (5) = 19.224, $p < 0.05$. The Hosmer and Lemeshow tests were also used to support the current model but their interpretation is completely different from the omnibus test. In this test, the significance value should be higher than 0.05 so that the model does fit the data. Table 1 shows that the chi-square value for the Hosmer and Lemeshow Test is 11.980 with a significance level of 0.101. This value is larger than 0.05; therefore, indicating accuracy for the model.

Table 1. Omnibus & Hosmer Tests of Model Coefficients

Test	Chi-square	Degrees of freedom	Significant value
Omnibus	19.224	5	0.002
Hosmer and Lemeshow	11.980	7	0.101

To calculate the variations in the dependent variable, the method of the Cox & Snell R^2 and Nagelkerke R^2 were supportive. According to these methods, Table 2 shows that around 17.5%-23.5% of the variability in the eyesight issues after the COVID-19 pandemic were considered by all the independent variables.

Table 2. Model Summary

-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
116.835	0.175	0.235

2.3. Model Characteristics

The classification table depicted in Table 3, which is obtained after the execution of logistic regression in IBM SPSS, explains how well the model is going to predict the correct category (facing eyesight issues/no eyesight issues after the COVID-19 pandemic) for each case. The sensitivity of the model is the percentage of the students having eyesight issues after COVID-19 pandemic, which were identified by the model in Table 3, which is primarily 52.4% of the students who are facing eyesight issues after COVID-19 pandemic.

Table 3. Classification Table

Observed		Predicted		
		Is the child facing any eyesight issues after COVID-19 pandemic?		Percentage Correct
		no	yes	
Is the child facing any eyesight issues after COVID-19 pandemic?	no	44	14	75.9
	yes	20	22	52.4
Overall Percentage				66.0

The model's specificity refers to the percentage of students who do not have eyesight issues after COVID-19 pandemic. In this model, the specificity is 75.9%. The model accurately predicted that students who did not have eyesight problems after the COVID-19 pandemic were indeed free of such issues.

3. RESULTS AND DISCUSSION

The model shows a complete picture of all the parameters measured in this study. Table 4 provides a detaileddata about the contributions of every

independent variable.

Table 4. Coefficients of Logistic Regression Model for Different Eyesight Issues Parameters

Independent variables	Coefficients (*B*)	S.E.	Wald	*df*	Sig.	Exp(*B*)	95% C.I. for EXP(*B*)	
							Lower	Upper
Gender of child	0.774	0.465	2.774	1	0.096	2.168	.872	5.389
Age of child	0.204	0.107	3.616	1	0.057	1.226	.994	1.513
What was the distance of eyes of the child from computer/phone screen?	-0.748	0.581	1.653	1	0.199	0.474	0.152	1.480
What is the maximum hours of screen exposure of the child?	0.876	0.517	2.867	1	0.090	2.402	0.871	6.622
Did the child have any eyesight issue before COVID-19 pandemic?	0.903	0.484	3.478	1	0.062	2.466	0.955	6.369
Constant	-3.206	0.998	10.316	1	0.001	0.041		

The direction and quality of the relationship between the dependent and independent variables are shown in the column B. In the model, the B value of the distance of eyes of the students from computer/phone screen is negative, which means that the distance is more than 16 inches and has less probability of having eyesight issues than if the distance is less than 16 inches. The other B values are positive, which reflects that if the age of students increased, the chances of having eyesight issues increases. Furthermore, the B value of gender is also positive, which means that female students has less probability of having eyesight issues than male

students. More than 3 hours of screening time is more harmful for the students and create more eyesight issues than the other students whose screening time is less than 3 hours. Similarly, students who were already facing vision problems have more possibility to have more severe vision problems after online education.

These values of B can be utilized in an equation to find the probability of the primary students having eyesight issues. These values are in log-odds units, which can be converted to probabilities. The following is the expression for the binary logistic regression model considering the aforementioned variables:

$$\log\left(\frac{p}{1-p}\right) = b_0 + b_1 x_{gender} + b_2 x_{age} + b_3 x_{distance} + b_4 x_{duration} + b_5 x_{already\ eyesight\ issues} \quad (3.1)$$

Where p, is the probability of having eyesight issues after COVID-19 pandemic $\log\left(\frac{p}{1-p}\right)$ in **Eq. (3.1)** is considered as a log of odds or link logit function while $\frac{p}{1-p}$ is taken as the odds ratio. The logistic regression equation in variables form is:

$$\log\left(\frac{p}{1-p}\right) = -3.206 + 0.774\, x_{gender} + 0.204\, x_{age} - 0.748 x_{distance} + 0.876\, x_{duration} + 0.903\, x_{already\ eye\ issues} \quad (3.2)$$

Applying antilog on both sides, the odds ratio will be equal to,

$$\left(\frac{p}{1-p}\right) = e^{-3.206+0.774\, x_{gender}+0.204\, x_{age}-0.748 x_{distance}+0.876\, x_{duration}+0.903\, x_{already\ eye\ issues}} \quad (3.3)$$

The probability of each eyesight issue parameter with different covariates can be easily depicted. **Eq. (3.4)** represents the probability equation generated from the model.

$$p = \frac{e^{-3.206+0.774\, x_{gender}+0.204\, x_{age}-0.748 x_{distance}+0.876\, x_{duration}+0.903\, x_{already\ eyesight\ issues}}}{1 + e^{-3.206+0.774\, x_{gender}+0.204\, x_{age}-0.748 x_{distance}+0.876\, x_{duration}+0.903\, x_{already\ eyesight\ issues}}} \ldots \quad (3.4)$$

In Table 4, column Exp (B) is the value of the odd ratio for each

independent variable. It shows the increase in probability of occurrence as the independent variable increases by one unit. In the model, the odds of a student having eyesight issues is 0.474 times higher for the student whose distance of eyes from the device is less than 16 inches than a child whose distance of eyes from the device is more than 16 inches, if all other factors are supposed to be constant. Similarly, the odds of a student having eyesight issues is 2.402 times higher for the student whose screen time is more than 3 hours than those students having screen time is less than 3 hours. Same as in the situation of suffering any other eyesight issues before COVID-19 pandemic, those students who are suffering any eyesight issues before COVID-19 pandemic, the eyesight issues is 2.466 times higher than those who not suffering any eyesight issues before online education, taking all other factors constant. The odd ratio of the gender is greater than 1, which represents that mostly male students have reported eyesight issues than female students. The odds of eyesight issues in female students decrease by a factor of 2.168 to male students when all other factors are kept constant. In the model, one continuous variable, age, is also included. The odd ratio of age is increased by a factor of 1.226 for a one-year increase in age. In Table 4, the 95% confidence intervals provide lower and upper bounds associated with the corresponding odds ratios. These are the limits where you can be 95% confident that they cover the true value of the odds ratio. Using the probability equation obtained in (4), Table 5 shows that all probabilities of having eyesight issues were measured with the impact of all independent variables.

As age is the continuous variable, maximum, minimum, and average age has been taken to estimate the probabilities. The lowest probability of having eyesight issues is 0.04156, which depicts a female primary student who is not suffering any eyesight issues before online education, at the age of 4 years, with the distance of more than 16 inches with screen and her exposure duration is less than 3 hours. While the maximum probability of having eyesight issues is 0.85753, which represents a male student who is already facing eyesight issues at the age of approximately 12 years, with a distance of fewer than 16 inches and his exposure duration is more than 3 hours. Figure 1 shows the probability of having eyesight issues in male students with the consideration of all the independent variables. While, Figure 2 shows the probability of having eyesight issues in female students with the consideration of all the independent variables.

Table 5. Probability Table of Having Eyesight Issues with the Covariates

Distance		Less than 16 inches				More than 16 inches			
Duration		Less than 3 hours		More than 3 hours		Less than 3 hours		More than 3 hours	
Eyesight condition before pandemic		Healthy	Unhealthy	Healthy	Unhealthy	Healthy	Unhealthy	Healthy	Unhealthy
Female	4 year	0.083	0.184	0.180	0.351	0.041	0.096	0.094	0.204
	≤8 year	0.171	0.338	0.332	0.551	0.089	0.194	0.190	0.367
	≤12 year	0.319	0.536	0.529	0.735	0.181	0.353	0.347	0.567
Male	4 year	0.165	0.328	0.323	0.540	0.085	0.188	0.184	0.357
	≤8 year	0.310	0.525	0.518	0.726	0.175	0.344	0.338	0.557
	≤12 year	0.503	0.714	0.709	0.857	0.324	0.542	0.535	0.740

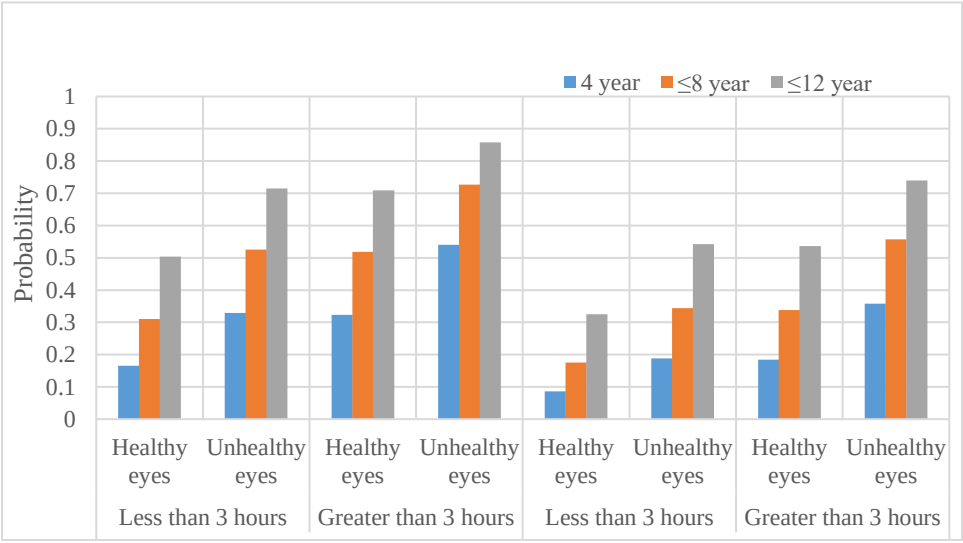

Figure 1. Probability of Eyesight Issues in Male Students

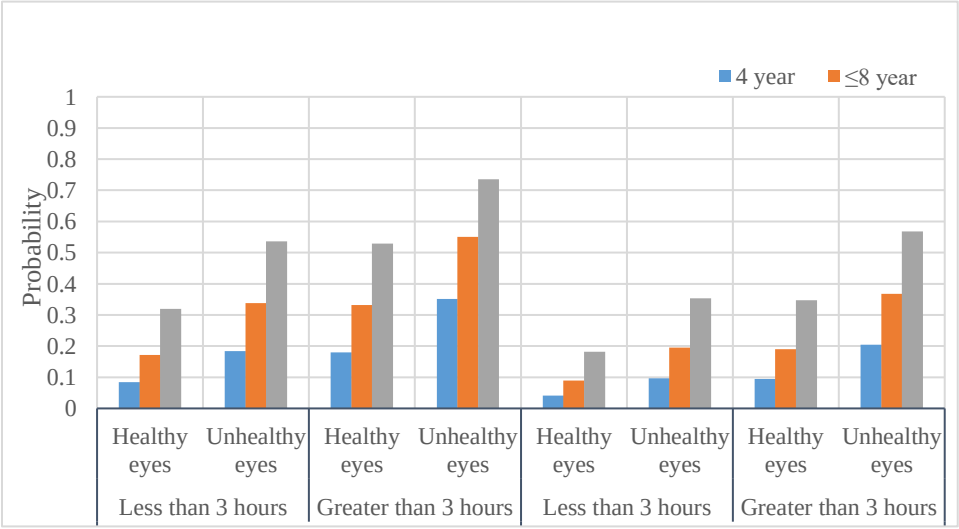

Figure 2. Probability of Eyesight Issues in Female Students

3.1. Conclusion

The current study deployed a logistic regression analysis, which estimated the probability of optical impairment in primary school children. Noticeably, these children were taking online classes during the COVID-19 pandemic. This research paper indicated that a logistic regression model

considered the explanatory variables of gender, age, eye distance from the device, duration of use, and previous vision problems to model eyesight abnormalities in primary school children. With the help of this model, it has been observed that male students have more chances than female students of developing eyesight issues. Furthermore, it was observed that the probability of experiencing eye problems increases when factors such as age, distance, and duration of online classes are extended. Additionally, if the child has preexisting eye disorders, the likelihood of developing eye issues increase. Thereby, it was identified that female students of 4 years of age have the lowest chance of having eyesight problems if they use devices with 16 inches of distance. This is because they are exposed for less than 3 hours and do not have any prior eye problems. Male students ranging between 9-12 years, using a screen with a distance of less than 16 inches over an extended period of up to 3 hours and who have already faced vision issues have the highest risk of having vision issues. Therefore, it is recommended that male students should wear eyeglasses or should maintain a proper screen distance to reduce the impact on their eyesight. Additionally, periodic eye exams enable them to detect earlier symptoms of any developing problems.

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