Myopia progression in Egyptian Urban children under the influence of online learning during the COVID-19 pandemic

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Received: 13-12-2022, Accepted: 3-1-2023, Published online:16-3-2023

EJO(MOC) 2022;3(1):32-40.

Short title*:* COVID-19 myopia progression

Abstract:

Purpose: To evaluate myopic progression in school-aged Egyptian urban children secondary to online learning during the COVID19 pandemic.

Patients and Methods: A cohort study of 105 children aged 8–16 years with myopia of -0.75D or greater. Inclusion criteria were the presence of hospital records for at least two years before presentation and one year after, minimum of 6 months of online learning. Patient demographics, type of device, duration of device use, and changes in myopia (over time) were recorded.

Results: The mean age was 12±2 with 51.4% males and 48.6% females. The average daily screen time was 5 ±1 hours. Tablets were the predominant device used (48.6%), 43.8% of children had a break time of 60 minutes, and 37.1% of children had > 2h of daily outdoor activities. The rate of annual myopia progression was significantly higher during the target period of online learning (MP(T) = -0.61 D±0.24) compared to myopia progression in the year before (MP(B) = -0.54 D ±0.2) and the year after (MP(A) = -0.53 D±0.21) (*p* value 0.005& 0.019 respectively). MP(T) significantly increased in children who stayed greater than or equal to hours in front of screen compared to the year before and after online learning (*P*=0.009, 0.017 respectively), with less than two-hour outdoor activity (*P* value 0.003 & 0.005 respectively) without taking a break (*P*=0.004).

Conclusion: Online learning and lack of outdoor activities during the COVID19 pandemic significantly accelerated myopia progression rate in Egyptian urban children.

Keywords: COVID19, myopia progression, online learning, home education

INTRODUCTION

Myopia progression or deterioration is an important world-wide concern as the increase in myopia in the last decade has been described by some authors as an epidemic[1]. There have been some estimates that half of the world's population will be myopic by 2050[2]. Some estimations have also been made and suggest that approximately five billion people will become myopic and over one billion with myopia above five diopters (D) by 2050[2,3].

To limit viral spread during the COVID19 pandemic, several countries had enacted stay at home orders. As a result of this, usually outdoor activities were constrained, and regulations such as home confinement, school closures, working from home, and online learning were applied by emergency laws[4]. These changes have been considered a predisposing/ aggravating factor for myopia progression[5,6]. The resulting dependency on screen/online-learning during the COVID19 pandemic influenced the myopia deterioration rate in what is described as 'Quarantine myopia'[7]. Over one billion children (May 2020) from over 140 countries were exposed to digital devices according to the United Nations Educational Scientific and Cultural Organization, as a result of educational/ social pandemic associated restrictions[8,9].

Worsening of myopia was reported in one study with myopic children before and during the COVID19 pandemic, with 62.4% of the children showing progression during the pandemic compared to 45.9% before the pandemic. During the pandemic, 45.9% of children showed an annual progression of 1 D, compared to 10.5% before the COVID19 pandemic[10].

As with most countries, once the WHO declared COVID19 a pandemic in March 2020, Egypt announced the enforcement of school closures and online learning began. During that time, myopia progression secondary to prolonged electronic device use and abstaining from outdoor activities was not thoroughly studied in the Egyptian urban student population. Thus, this study intended to evaluate myopia progression caused by excessive electronic use among Egyptian school-age urban children during the pandemic quarantine era and compare such progression to the year before and the year after and factors related to that progression.

MATERIALS AND METHODS

Study Design: A Cohort longitudinal study design was decided. This study followed the Helsinki Declaration of World Medical Association in 1964. Ethical approval was granted from the International Eye Hospital ethical committee (no.21375). Informed consent was obtained from the parent/ legal guardian of the child included in the study.

Inclusion criteria: A myopia of -0.75 D or greater, urban living, the presence of hospital records for a minimum of two years before presentation and the presence of cycloplegic refraction values. A minimum of six months of online learning and the presence of one year follow-up record were two important criteria.

Exclusion criteria: Myopia under -0.75 D, astigmatism more than 2 D, presence of amblyopia or squint, keratoconus, glaucoma, cataract, retinal pathology, a history of eye surgery or trauma, or contact lens use.

Methods: The right eyes of 105 children between 8–16 years of age were included with a diagnosis of bilateral myopia. They were presented to the outpatient clinic of the International Eye Hospital between December 2020 and March 2021with a previous two-year record in the hospital. They were followed for a further year. Refractive data for 2018, 2019, early 2020, the time of presentation in late 2020 and first quarter of 2021, and one year later were extracted from the medical records. The spherical equivalent (SE) values were noted; SE 1 (late 2018 & early 2019), SE 2 (late 2019 & early 2020), SE 3 (late 2020 & early 2021) target period after at least 6 months of online learning, SE 4 (late 2021 & early 2022).

Myopic progression in one year ≤ 0.50D was identified as mild, between 0.50–1D as moderate, and 1D or more as severe[11]. An Auto refractometer (Topcon KR-8900 Standard Auto-refractometer, Tokyo, Japan) was used for refractive measurements and confirmed with cycloplegia. IOP was measured by Goldmann applanation tonometer topped on Rodenstock slit lamp (RO-5000, Nurnberg; Germany) and posterior segment was examined by indirect ophthalmoscope (IO-α, NEITZ INSTRUMENTS CO.LTD; Japan).

Patient demographics (age, gender), educational level of the mother, the type of electronic device the child has access to, duration of device use, type of residence, and the time spent in outdoor activities for the child were all recorded.

Statistics:

Data management and analysis were performed using Statistical Package for Social Sciences (IBM SPSS Statistics for Windows, IBM Corp. Released 2021, Version 28.0. Armonk, NY: IBM Corp). Numerical data were summarized using means and standard deviations or medians and/or ranges, as appropriate. Categorical data were summarized as numbers and percentages. Estimates of the frequency were done using the numbers and percentages. Numerical data were explored for normality using Kolmogorov-Smirnov test and Shapiro-Wilk test.

Comparisons between two groups for non-normally distributed numeric variables were done by Mann-Whitney U test. Comparison between two related groups of non-normally distributed numeric variables, were done by Wilcoxon test. Comparisons between more than 2 groups were performed by

Kruskal-Wallis for non-normally distributed variables, then followed by post hoc if needed (Post Hoc comparison was done and P value was adjusted using Bonferroni adjustment). Comparison between multiple related groups of non-normally distributed numeric variables was done using Friedman test. To measure the strength of association between non-normally distributed measurements, Spearman's correlation coefficients were calculated (r is the correlation coefficient & it ranges from -1 to +1). All tests were two tailed and probability (p-value) ≤ 0.05 was considered significant.

RESULTS

In this cohort longitudinal study data was retrieved from patients' records from years 2018, 2019, 2020, 2021, as well as the first half of 2022. The study involved 105 children recruited from the International Eye Hospital outpatient clinic medical records. The mean age was 12±2 years ranging from (8-16) years, with nearly equal distribution of both sexes; 51.4% and 48.6% for male and female respectively. Forty-one percent of their mothers achieved university education. The average duration of glasses use was 3±1 years. With the online learning style adopted during the COVID19 pandemic, the average daily screen time was 5±1 hour. Near half of children were using tablet (48.6%). Only 43.8% of children were taking a break every 60 min and only about one third of children (37.1%) were performing outdoor activities. Most children were living in an apartment (70.5%). The sociodemographic characteristics of the participants are shown in Table 1.

The mean spherical equivalent (SE) increased by time from 2018 till 2022 and this increase is statistically significant (*P* value <0.001). SE 1 (late 2018 and early 2019) was -3.6 ±2.3, SE 2 (late 2019 and early 2020) was -4.1 ±2.2, SE 3 (late 2020 & early 2021; the target period after at least 6 months of online learning) was -4.7 ±2.3, SE 4 (late 2021 and early 2022) was -5.2 ±2.4 (Fig.1).

Table 1: Sociodemographic characteristics of study participants

	Mean ± SD
Age (Years)	12 ±2
Duration of glass use (years)	3 ±1
Average daily screen time (hours)	5 ±1
Sex	n=105 (%)
Female	51 (48.6)
Male	54 (51.4)
School	
Primary	66 (62.9)
High school	39 (37.1)
Mother's educational level	
Illiterate	7 (6.7)
Primary	20 (19)
High school	35 (33.3)
University	43 (41)
Device type	
PC	24 (22.9)
Smart phone	30 (28.6)
Tablet	51 (48.6)
Break every 60 minutes	
No	59 (56.2)
Yes	46 (43.8)
Outdoor activity	
< 2 Hours	66 (62.9)
≥ 2 Hours	39 (37.1)
House type	
Apartment	74 (70.5)
Single home	31 (29.5)

SD: Standard deviation

The rate of annual myopia progression was significantly higher during the target period (MP(T) = -0.61 ±0.24) compared to myopia progression in the year before online learning (MP(B) = -0.54 ±0.2) and the year after online learning (MP(A) = -0.53 ±0.21) (*p* value 0.005 and 0.019 respectively) (Fig.2). The results for the spherical equivalent and myopia progression are shown in Table 2.

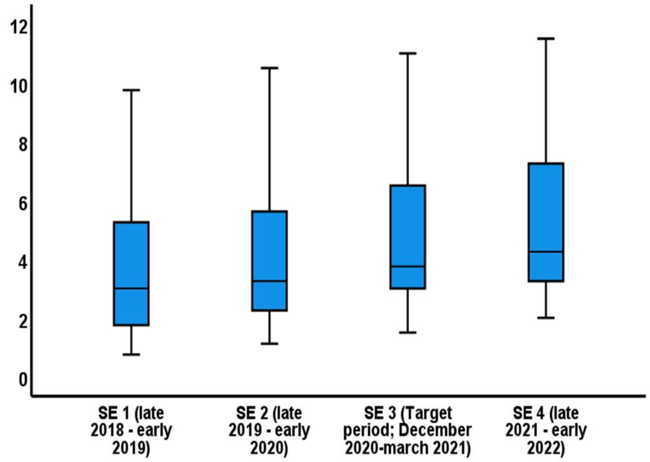

Figure (1): Box plot representing spherical equivalent (SE) in diopters during different time periods.

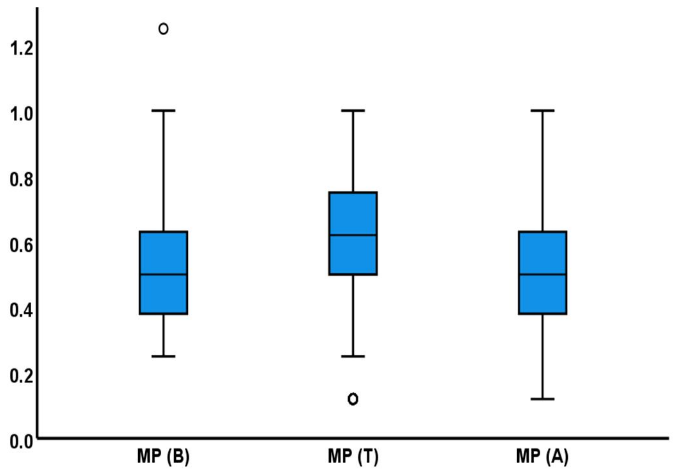

Figure (2): Box plot representing myopia progression (MP) in diopters during different time periods; MP(B): the year before COVID 19; MP(T): during the pandemic; MP(A): the year after quarantine.

Table 2: Spherical equivalent (SE) and myopia progression of the studied group.

	Mean ±SD	*P* value
SE 1	3.6 ±2.3	<0.001
SE 2	4.1 ±2.2	
SE 3	4.7 ±2.3	
SE 4	5.2 ±2.4	
MP (B)	0.54 ±0.2	0.001*
MP (T)	0.61 ±0.24	
MP (A)	0.53 ±0.21	

SE: spherical equivalent, MP: myopia progression, MP (B): Myopic Progression in the year Before online learning, MP (T): Myopic Progression in the Target period, MP (A): Myopic Progression in the year after online learning, * Myopia rate of progression was significantly higher in MP (T) compared to MP (B) and MP (A) (*P* value 0.005 & 0.019 respectively)

MP(T) was mild (≤ 0.5D) in 46 participants (43.8%), moderate (between 0.5 and 1D) in 51 participants (48.6%) and severe (≥ 1D) in 8 participants (7.6%).

The spherical equivalent increased significantly by time in all children whether spending either less than five hours or greater than or equal five hours in front of the screen, but myopic progression in children who stayed greater than or equal five hours in front of screen showed significant increase during the target period compared to the year before and after online learning (*P*=0.009, 0.017 respectively) (Table 3).

Table 3: Spherical equivalent and myopia progression in relation to daily screen time.

	Daily screen time (hours)		
	< 5 Hours	**≥ 5 Hours**	
	Mean ± SD	**Mean ± SD**	***P* value**
SE 1	4.2 ±2.2	3.3 ±2.1	0.024
SE 2	4.7 ±2.3	3.8 ±2.2	0.037
SE 3	5.3 ±2.5	4.5 ±2.2	0.068
SE 4	5.9 ±2.6	5 ±2.3	0.081
***P* value (within group)**	<0.001	<0.001	
MP (B)	0.54 ±0.22	0.54 ±0.19	0.794
MP (T)	0.6 ±0.28	0.61 ±0.22	0.990
MP (A)	0.52 ±0.2	0.54 ±0.22	0.935
***P* value**	0.437	0.002	

SE: spherical equivalent (SE), MP (B): Myopic Progression in the year Before online learning, MP (T): Myopic Progression in the Target period, MP (A): Myopic Progression in the year after online learning, *P* value <0.05 is considered significant

The spherical equivalent increased by time in children whether they took a break every 60 minutes or not. Myopic progression in children who did not take break every 60-minute showed significant increase during the target period compared only to the year before online learning (*P*=0.004) but not the year after (Table 4).

Table 4: Spherical equivalent and myopia progression in relation to having break every 60 minute or not.

	Break every 60 minutes		
	Yes	No	*P* value
	Mean±SD	Mean±SD	
SE 1	3.73 ±2.36	3.42 ±2.02	0.663
SE 2	4.31 ±2.43	3.93 ±2.09	0.535
SE 3	4.97 ±2.5	4.52 ±2.14	0.516
SE 4	5.5 ±2.57	5.04 ±2.28	0.454
***P* value (within group)**	<0.001	<0.001	
MP (B)	0.58 ±0.22	0.51 ±0.17	0.132
MP (T)	0.62 ±0.24	0.6 ±0.24	0.780
MP (A)	0.55 ±0.18	0.52 ±0.23	0.350
***P* value**	0.173	0.004	

SE: spherical equivalent (SE), MP (B): Myopic Progression in the year Before online learning, MP (T): Myopic Progression in the Target period, MP (A): Myopic Progression in the year after online learning, *P* value <0.05 is considered significant

The spherical equivalent increased by time in children whether having outdoor activity either less than two hours or greater than two hours, but myopic progression in children who had outdoor activity less than two hours showed significant increase during the target period compared to the year before and after online learning (*P*=0.003, 0.005 respectively) (Table 5).

Table (5): Spherical equivalent and myopic progression in relation to outdoor activity.

	Outdoor activity		
	< 2 Hours	≥ 2 Hours	*P* value
	Mean ±SD	Mean ±SD	
SE 1	3.71 ±2.22	3.3 ±2.1	0.404
SE 2	4.24 ±2.33	3.85 ±2.1	0.462
SE 3	4.87 ±2.39	4.47 ±2.17	0.493
SE 4	5.39 ±2.49	4.99 ±2.27	0.571
***P* value (within group)**	<0.001	<0.001	
MP (B)	0.53 ±0.2	0.55 ±0.2	0.794
MP (T)	0.61 ±0.23	0.6 ±0.25	0.829
MP (A)	0.52 ±0.21	0.55 ±0.2	0.194
***P* value**	<0.001	0.57	

SE: spherical equivalent (SE), MP (B): Myopic Progression in the year Before online learning, MP (T): Myopic Progression in the Target period, MP (A): Myopic Progression in the year after online learning, *P* value <0.05 is considered significant

There was no significant correlation between age or duration of glasses use to myopic progression (Table 6).

Table (6): Correlation between age and glass use duration to myopic progression.

	Age		Duration of glass use (Years)		
	r	*P* value	r	*P* value	Degree of correlation
MP (B)	0.04	0.674	-0.02	0.836	Non-significant
MP (T)	0.06	0.580	0.02	0.867	Non-significant
MP (A)	0.12	0.207	0.06	0.549	Non-significant

r is the correlation coefficient & it ranges from -1 to +1, *p* value <0.05 is considered significant, MP (B): Myopic Progression in the year Before online learning, MP (T): Myopic Progression in the Target period, MP (A): Myopic Progression in the year after online learning.

Myopic progression in children living in an apartment showed significant increase during the target period compared to the year before and after online learning (*P*=0.009, 0.029 respectively) (Table 7). The relation was insignificant for those living in a single house.

Table (7): Myopic progression in relation to house type.

	House type		
	Apartment	Single home	
	Mean ± SD	Mean ± SD	*P* value
MP (B)	0.53 ±0.19	0.57 ±0.2	0.341
MP (T)	0.6 ±0.24	0.63 ±0.24	0.538
MP (A)	0.52 ±0.22	0.57 ±0.19	0.141
***P* value**	0.003	0.330	

MP (B): Myopic Progression in the year Before online learning, MP (T): Myopic Progression in the Target period, MP (A): Myopic Progression in the year after online learning, *P* value <0.05 is considered significant

Myopic progression in children using tablet showed significant increase during the target period compared to the year before and after online learning (P <0.001, 0.010 respectively) (Table 8).

Table (8): Myopic progression in relation to device type.

	Device type			
	PC Mean ± SD	Smart phone Mean ± SD	Tablet Mean ± SD	*P* value
MP (B)	0.56 ±0.26	0.58 ±0.18	0.50 ±0.17	0.140
MP (T)	0.57 ±0.28	0.61 ±0.26	0.62 ±0.21	0.760
MP (A)	0.53 ±0.24	0.54 ±0.21	0.53 ±0.2	0.804
***P* value**	0.988	0.469	<0.001	

MP (B): Myopic Progression in the year Before online learning, MP (T): Myopic Progression in the Target period, MP (A): Myopic Progression in the year after online learning, *P* value <0.05 is considered significant

DISCUSSION

Uncorrected myopia is an undeniable limitation to the performance of children in education especially in the pre-university years, as well as in the quality of life. From another perspective, myopia is a major cause of legal blindness and can cause serious complications. One of the factors proved by other studies is that prolonged online education is strongly correlated with deterioration of myopia and the positive effect of daylight and outdoor activities in slowing the progression of myopia in children is certain[12].

Our study included 105 urban living children that were seen in the outpatient clinic between December 2020 and March 2022. Schools in Egypt were closed, and quarantine along with online learning started in April 2020 so that each of our participants was in the period of online learning for at least six months. The current study is another proof of the negative impact of online learning and prolonged near work on worsening of myopia in school children in the age range between 8-16y (mean 12±2). The myopia in those children deteriorated in the year of quarantine and online learning significantly compared to the year before and the year after (*P*=0.005, 0.019 respectively). That deterioration did not correlate to age nor duration of glasses use. The deterioration in myopic children was mostly either mild (43.8%) or moderate(48.6%).

The results of the study by Aslan and Sahinoglu-Keskek[13] on Turkish children revealed that myopic progression during the year of 2020 within the age range of 8–17 years, was significantly greater than in the previous years. They also claimed that spending two hours or more daily in an outdoor activity and living in a detached house were associated with reduced progression. However, no significance was found regarding the type and duration of digital device usage on myopic progression. [13] Unlike their study which examined myopic progression in the online year to the previous years, in our study myopic progression in that year was compared to a year before and a year after with a more solid confirmation of the effect of online learning and the effect of withdrawal of sun light and outdoor activity on more rapid myopic progression[13]. Additionally, the study by Aslan and Sahinoglu-Keskek in 2021 recruited their subjects between August and December 2020, with only few months of previous online learning and quarantine. In our study, to get more reliable results, children between December 2020 and the first quarter of 2021 were included with a longer duration of exposure to online learning[13].

Our study found that spending more than five hours' screen time was the cause of significant increase compared to the year before and after online learning. It is difficult to explain the relationship between myopia progression and the duration of screen time of digital display devices. A theoretical explanation is that dopamine release in the retina is stimulated by daylight. Dopamine can reduce the axial elongation of the eye[14,15]. Spiperone, a dopamine antagonist, has been shown to inhibit the protective effect of light against the increase of the ocular axial length in experimental models[16].

Also, studies have revealed that the dopaminergic system in the frontal lobe is activated using a digital device. [17] The effect of such display devices on the retinal dopamine levels is not yet known. The relationship of long-term exposure to digital device screens with myopia is still controversial and some studies support this relationship like our study, while others claim the opposite[18,19]. If online learning is mandated again due to another pandemic or new strain of coronavirus, it is highly recommended to limit the screen time to less than five hours. In the current study myopic progression in children who stayed greater than or equal five hours in front of screen showed significant increase during the target period compared to the year before and after online learning (*P* value 0.009 and 0.017 respectively). It is thought that taking a break every 60 minutes might be useful as the current study found that myopic progression during the target period in children who did not take a break every 60 minutes correlated significantly to the year before online learning (P value 0.004) but not the year after. That was different from the study by Aslan and Sahinoglu-Keskek[13] which mentioned that having a break every 30 minutes did not correlate significantly with the amount of myopia deterioration in the pandemic year[13].

Wang et al.[20] conducted a study on more than a hundred thousand children aged /between six and eight years in 2021. The main drawback was that they used the ‘photo-screening’ test. Such photo-screening devices tend to exaggerate the results and rely on the experience of the professional using the device[21,22]. Hence, they found that the myopia progressed 1.4 to 3 times during the pandemic year compared to the previous five years. Such photo-screening devices may be useful in non-verbal and pre-verbal children. In our study, we included only cycloplegic refractions to get more reliable results as indicated by the general ophthalmological approach in school-age children[23].

In our study, myopic progression in children who had outdoor activity less than 2 hours showed a significant increase during the target period compared to the year before and after online learning (P-value 0.003 and 0.005 respectively). Similarly, and as previously mentioned, Aslan and Sahinoglu-Keskek observed a 33% less progression in myopic children with two hours of outdoor activity daily, even though the duration spent in front of the screen was similar to those who spent less than 2 hours. In the same study, they claimed that outdoor activities had a protective effect on myopia progression. They claimed that their results point to the fact that environmental factors are among those that affect myopia progression[13].

Similarly, other studies claimed that outdoor activities decrease the progression of myopia. He et al. reported that every extra 40 minutes of daily outdoor activities results in 23% decrease in myopic progression[24]. Wu et al. have assumed that spending more than eleven hours a week in outdoor activities will result in decrease of myopia progression by 53%[25]. Generally, it is assumed that two hours of daily outdoor activities will decrease myopia progression in school age children[7].

Likewise, we found that myopic progression in children living in an apartment showed a significant increase during the target period compared to the year before and after online learning (P value 0.009 and 0.029 respectively). For those who were living in a single house, the correlation was insignificant. Living in a single or detached house would give the chance for more outdoor activities. Similarly, Aslan and Sahinoglu-Keskek concluded that the type of house is one of those environmental factors and might be considered as an independent risk factor for myopia progression. In the same context, an Australian study claimed the same assumption between the type of the house and the progression of the myopic refractive error. In that study, it was claimed that myopia is more commonly reported in children living in apartment buildings compared to those living in single or detached houses[18]. Wu et al. reported an increase in the myopia prevalence with increasing number of floors in the building[26].

To our knowledge, this is the first study the progression of myopia in Egypt under the influence of the pandemic and the first to compare myopia progression to the year before and the year after unlike other studies that compared it to the years before only. An important limitation of this study is the possible bias resulting from the collected information being self-reported by the parents and the accuracy of which may be uncertain. We investigated the mother’s educational level in a trial to affirm the integrity of the information obtained from the parents. Most of the mothers were university graduates (41%) or high school graduates (33.3%).

CONCLUSION AND RECOMMENDATIONS

This study added the fact that home education and digital screen use during the COVID19 pandemic has increased the myopia progression rate in Egyptian urban children, compared to the previous year and the year after. This increase has been found to be related to the duration of outdoor activities. Staying more than two hours daily in outdoor activities and living in a single house were both found to be potential halting factors for myopic deterioration. Limiting the device or screen time to less than five hours, taking a break every 60 minutes and more than two hours of open-air activities are very important recommendations to ensure that myopia does not deteriorate to avoid serious complications later in life.

Abbreviations:

COVD19 – coronavirus disease 2019

D – diopter

MP – myopic progression

SE - spherical equivalent

WHO – world health organization

Declarations:

Ethical Consideration: This study was conducted according to the Helsinki Declaration of World Medical Association 1964. Ethical approval was granted from the International Eye Hospital ethical committee (no.21375). An informed consent was obtained from the guardians/ parents of the children prior to study.

Funding: Self-funded

Acknowledgments: None.

Competing Interests: No conflict of interest to disclose.

Data Availability: All data is available within the manuscript. Any additional information required will be available upon request.

Consent to publish: All authors of this manuscript approve of its submission in this final form.

Author Contributions: All authors of this manuscript have equally taken part in the whole process (Idea, writing, figures and tables, data collection, data analysis, etc.). All authors of this manuscript were put as authors according to the International Committee of Medical Journal Editors (ICMJE) guidelines.

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