Original Article

# The Prevalence and Causes of Low Vision and Visual Impairment in School-Aged Children: The Shiraz Pediatric Eye Study

**Mohammad Reza Talebnejad[1], Mohammad Reza Khalili[1], Zahra Tajbakhsh[1,2], Masoumeh Beygom Masoumpour[1], Hamideh Mahdaviazad[1,3], Elham Mohammadi[1], Maryam Keshtkar[1], Mohammad Hossein Nowroozzadeh[1]**

[1]Poostchi Ophthalmology Research Center, Department of Ophthalmology, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran, [2]School of Optometry and Vision Science, University of New South Wales, Sydney, Australia, [3]Department of Family Medicine, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran

## Abstract

**Purpose:** To determine the prevalence and causes of visual impairment (VI) in Shiraz schoolchildren aged between 6 and 12 years.

**Methods:** In the present population-based study, stratified random sampling was used to select 2400 schoolchildren aged 6–12 years from all four educational districts of Shiraz, Iran. Using the definitions of the World Health Organization, VI was defined as best-corrected visual acuity (BCVA) ≤0.5 logMAR (20/60) in the better eye, and blindness as BCVA worse than 1.3 logMAR (20/400) in the better eye. The low vision was defined as BCVA equal to or worse than 0.5 logMAR (20/60) in either eye. Data were recorded from a detailed interview and ocular examination of each eligible student.

**Results:** The mean age of the students was 9.1 ± 1.6 years. The prevalence of VI was 3/2001 (0.14%). The cause of VI in all these three patients (100%) was amblyopia due to high refractive errors (high ametropia and astigmatism). Regarding the main refractive errors leading to VI among these three patients, one patient had bilateral high hyperopia (compound hyperopic astigmatism), one of them had bilateral high astigmatism, and the other one had compound myopic astigmatism. According to a visual acuity of less than or equal to 20/60 in at least one eye, 9/2001 (0.4%) of children had low vision.

**Conclusions:** This study revealed a low prevalence of VI in a sample of 6- to 12-year-old school-aged children. Amblyopia in the setting of high ametropia and astigmatism were the most common causes of VI.

**Keywords:** Amblyopia, Refractive error, Schoolchildren, Visual impairment

**Address for correspondence:** Mohammad Reza Khalili, Poostchi Ophthalmology Research Center, Department of Ophthalmology, Shiraz University of Medical Sciences, Zand Street, Shiraz, Fars, Iran.
E-mail: khalilimr57@gmail.com
**Submitted:** 12-May-2021; **Revised:** 27-Mar-2022; **Accepted:** 04-Apr-2022; **Published:** 30-Nov-2022

## Introduction

Visual impairment (VI) is an important world public health problem. It is a global health concern, especially in the pediatric population. The global burden of VI is enormous. It has been estimated that all over the world, about 259 million people are suffering from VI, 217 million of whom have only VI, and 42 million are blind.[1] Without effective interventions and due to the increasing trend, it is estimated that the number of blind people worldwide will reach 76 million in 2020.[2] Since the last two decades, the prevalence and causes of low vision and blindness have been investigated in many countries. The

Access this article online

Quick Response Code:

Website: www.jcurrophthalmol.org

DOI: 10.4103/joco.joco_153_21



**How to cite this article:** Talebnejad MR, Khalili MR, Tajbakhsh Z, Masoumpour MB, Mahdaviazad H, Mohammadi E, *et al*. The prevalence and causes of low vision and visual impairment in school-aged children: The Shiraz pediatric eye study. J Curr Ophthalmol 2022;34:333-40.

prevalence of blindness and low vision has been reported to be from 0.3% to 5.6% and 1.1% to 16%, respectively.[3] It has been estimated that about 24 million people are visually impaired in the Eastern Mediterranean region, including about 5 million blind and 19 million people with only visual impairment.[4] The prevalence of blindness and low vision in different provinces in Iran has been reported variably from 0.39% to 6.9%.[5-8]

It has been stated that about 80% of the world's blindness is either preventable or curable. Despite considerable efforts and application of national blindness prevention programs in many developing countries, the number of blind and low vision patients seems to be growing around the world. The prevalence of blindness in developing countries is higher than that of the developed countries, and about 90% of the world's blind patients live in developing countries.[9,10] According to the World Health Organization (WHO) statistics in 2010, 19 million children under the age of 15 were visually impaired, and about a total of 1.4 million children were irreversibly blind. About two-thirds of them were from Asia. Of those with VI, 7 million cases were visually impaired due to causes other than uncorrected refractive errors.[11,12]

It has been reported that 30%–72% of childhood low vision is avoidable. The burden of childhood VI and blindness is huge, and by affecting an individual's learning, communication, and future employment, it has lifelong social and economic consequences. Due to the significant impact and potentially preventable nature of VI and blindness of pediatric population, it has been considered a high priority within the WHO's Vision 2020: the Right to Sight program, a global initiative of the WHO and the International Agency for the Prevention of Blindness.[13,14] The Iranian Ministry of Health has joined the Vision 2020 WHO program to eliminate avoidable blindness. The prerequisite for such a mission is to collect population-based eye health data among children from different parts of our country. To contribute to such a mission, we conducted a population-based study including schoolchildren aged 6–12 years from all four educational districts of Shiraz, the largest city of Fars, a province in the south of Iran. The present study aimed to determine the prevalence and causes of low vision, including VI and blindness in these school-aged children from Shiraz, Fars Province.

## Methods

The Shiraz Pediatric Eye Study is a prospective cross-sectional research that enrolled school-aged children between 6 and 12 years old from September 2015 to March 2016. This study aimed to investigate the prevalence of childhood VI in elementary school-aged children of Shiraz. A detailed description of the design and method of this study has previously been published.[15] The Ethics Committee of Shiraz University of Medical Sciences approved the study protocol (IR.SUMS.REC.1394.S689). The study was conducted in accordance with the tenets of the Declaration of Helsinki. The aims and objectives of the study were explained, and written informed consent was obtained from the students' parents.

Two-stage stratified random sampling was used to select schoolchildren aged 6–12 years from all four educational districts of Shiraz affiliated to the Ministry of Education. Out of a total of 132,512 elementary schoolchildren in the survey area, 1.8% were selected to enroll in the study. After the recruitment process that started with coordination and permission of the Educational Department, the selected students received an invitation card. After that, all participants completed the questionnaire including information on basic demographics and parents' socioeconomic status, past medical history, drug history, and eye health history of each eligible student. Detailed information was also collected on many variables, including age, sex, family members, birth order, history of consanguineous marriage, parental education, parental occupation, history of systemic diseases, history of drug use, neonatal history, and history of ocular disorders in children and their first-degree relatives. Then, ocular examinations were performed by three experienced optometrists, two ophthalmologists, and one pediatric ophthalmologist. At the last step, students with suspected ocular abnormalities were referred to ophthalmic subspecialty services for further management. Students from special schools for disabled children, including blind and low vision children, were excluded from the study. In addition, students whose parents did not sign our consent form were excluded.

Uncorrected visual acuity (UCVA) and best spectacle-corrected visual acuity were measured by optometrists in a distance of 6 m (20 feet) using a Snellen E chart (LED visual chart projector, LC13, MEDIZS Inc., Korea). Refractive errors were measured with a Topcon autorefractometer (RM-8900, Tokyo, Japan). Refinement of the results was performed by expert optometrists using a manual retinoscope. Then subjective and cycloplegic refraction was performed and recorded for each eye separately. For cycloplegic refraction, cyclopentolate 1% eye drop was applied twice with an interval of 10 min.

Twenty minutes after the last application of cyclopentolate eye drops, cycloplegic refraction was performed.

Strabismus and motility examinations were performed to detect binocular disorders. To assess extraocular muscle performance, cover-uncover and motility tests were performed in nine gaze positions. The degree of heterophoria and heterotropia was measured. The magnitude of total deviation and manifest strabismus were measured for both far and near distances using a prism and alternative cover test methods and simultaneous prism and cover tests, respectively.

Stereopsis was measured at a distance of 40 cm using Polaroid glasses (Titmus test) and recorded. The stereoacuity worse than 40 s of arc was considered abnormal. The near point of convergence (NPC) was determined by placing a fixation object in a distance of 40 cm in front of the participant's head. The object was moved toward the child until one eye lost fixation. The NPC was recorded as the point at which the eye

lost fixation and the object moving toward the eyes was first perceived as two separate images.

The anterior segment of the eye was examined by a pediatric ophthalmologist using a slit-lamp biomicroscope (BM 900, Haag-Streit, Switzerland). Optic disc and macula were also evaluated using a Volk 90 D condensing lens.

VI and blindness were classified according to the definitions of the WHO, 10th Revision of the International Classification of Diseases-10 as follows.

VI was defined as visual acuity ≤0.5 logMAR (20/60) with best correction in the better eye.[16] Low vision was defined as a visual acuity equal to or worse than 0.5 logMAR (20/60) with best correction. Blindness was defined as visual acuity worse than 1.3 logMAR (20/400) with best correction in the better eye.[16] Moreover, amblyopia was defined as loss of visual acuity in the absence of an organic defect that is optically uncorrectable. Unilateral amblyopia was described as a two-line difference in best-corrected visual acuity (BCVA) between the two eyes or vision in the amblyopic eye <20/30, plus at least one of the following conditions: strabismus or history of strabismus surgery, anisometropia consistent with the worse eye (i.e., >1.00 diopter [D] spherical equivalent anisohyperopia, >3.00 D SE anisomyopia, or >1.25 D anisoastigmatism), or evidence of present or past visual axis obstruction (e.g., cataract, aphakia, significant corneal opacity, ptosis, or eyelid hemangioma).

Bilateral amblyopia was referred to as bilateral loss of BCVA with a history of significant bilateral ametropia (i.e., >5.00 D SE hyperopia, >6.00 D SE myopia, or >2.50 D astigmatism) or bilateral visual axis obstruction.

### *Statistical analysis*

Statistical analysis was performed using the statistical software package version 26.0 (SPSS Inc., Chicago, IL, USA) by a qualified statistician. Both descriptive and analytic statistics were used. The normality of data was examined by the Kolmogorov–Smirnov test. $P < 0.05$ was considered statistically significant.

## Results

Overall, 2001 students out of 2400 selected students (response rate: 83.3%) participated in the study, and their data were analyzed. Five cases had low vision in the left eye, 1 case in the right eye, and 3 cases (cases 1, 2, and 3) in both eyes [Table 1].

The prevalence of VI was 3/2001 (0.14%). The cause of low vision in all these three patients (100%) with VI was amblyopia due to high refractive errors (high ametropia and astigmatism). Regarding the main refractive errors leading to VI among these three patients, one patient had bilateral high hyperopia (compound hyperopic astigmatism), one had bilateral high astigmatism (mixed astigmatism), and the other patient had compound myopic astigmatism.

The first patient was a 12-year-old girl. Her cyclorefraction was OD: +7.75 − 1.0 × 120 and OS: +8.50 − 1.50 × 50. She has worn glasses since 7 years of age, and her present glass prescription was OD: +6.25 and OS: +6.00. Ocular motor and slit-lamp examinations were unremarkable. Fundus examination, including optic nerve and macula, was normal.

The second patient was an 8-year-old boy. His cyclorefraction was OD: +1.25 − 4.50 × 10 and OS: + 0.75 − 3.75 × 170. He has been wearing glasses since he was 6 years old, and the present glass prescription was OD: +0.25 − 2.00 × 180 and OS: +0.00 − 1.75 × 170. Ocular motor examination revealed right-beating jerk nystagmus that was characterized as congenital motor nystagmus. Fundus examination, including the optic nerve, was unremarkable.

The third patient was an 8-year-old boy. His cyclorefraction was OD: −6.25 − 4.50 × 10 and OS: −7.50 − 2.75 × 145. He has used glasses since he was 1 year old, and the present glass prescription was OD: −6.00 − 3.00 × 20 and OS: −8.00 − 2.00 × 150. Ocular motor examination revealed 20 alternating intermittent exotropia (Far = near) and a jerk nystagmus (congenital). Slit-lamp and fundus examinations (including optic nerve and macula) were normal.

Table 2 summarizes the logMAR visual acuities of both eyes in children who had VI according to a visual acuity of less than 20/60 in the better eye. Two children were male, and one was female. The mean (±standard deviation [SD]) age was 9.33 years (SD = 2.30). One patient was from educational district 2, and two patients were from educational district 3. The number of children in their family was three in one patient

**Table 1: Descriptive statistics of nine patients with low vision in at least one eye**

| | *n* | Minimum | Maximum | Mean |
|---|---|---|---|---|
| Presenting.VA.OD (decimal) | 9 | 0.2 | 1.0 | 0.51 |
| Presenting.VA.OS (decimal) | 9 | 0.1 | 1.0 | 0.34 |
| Dry refraction: Sph_OD | 9 | −6.25 | 7.25 | 1.38 |
| _cyl_OD | 9 | −5.50 | 0.00 | −1.88 |
| Cyl_Axis_OD | 9 | 0.00 | 170.00 | 72.55 |
| _sph_OS | 9 | −7.50 | 8.25 | 1.61 |
| _cyl_OS | 9 | −5.00 | 0.00 | −2.13 |
| Cyl_Axis_OS | 9 | 0.00 | 175.00 | 100.44 |
| Cycloref_sph_OD | 9 | −6.00 | 10.00 | 2.27 |
| Cycloref_sph_OS | 9 | −7.25 | 9.25 | 2.47 |
| Cycloref_cyl_OS | 9 | −5.75 | 0.00 | −2.25 |
| Cycloref_cyl_OD | 9 | −5.50 | 0.00 | −1.83 |
| Cycloref_Axis_OD | 9 | 0.00 | 170.00 | 73.55 |
| Cycloref_Axis_OS | 9 | 0.00 | 180.00 | 101.22 |

**Table 2: The decimal and logMAR visual acuities of both eyes in children who had visual impairment according to a visual acuity of <20/60 in the better eye**

| Patients | OS_logMAR (decimal) | OD_logMAR (decimal) |
|---|---|---|
| 1 | 1 (0.1) | 0.8 (0.2) |
| 2 | 0.8 (0.2) | 0.8 (0.2) |
| 3 | 0.5 (0.3) | 0.5 (0.3) |

and two in the others. One child was the first child of his family, and two of them were the second offspring. One out of three patients had a history of consanguineous marriage. The mothers of three patients were housekeepers. One patient had a history of premature birth with no evidence of retinopathy due to prematurity. One patient had G6PD deficiency.

None of the patients had a history of heart diseases, renal disorders, allergy, diabetes, hematologic disorders, or malignancy. Furthermore, none of them had a history of eye trauma. Three out of three patients (100%) wore eyeglasses due to refractive errors. However, the correction had started at a later age, and the prescriptions were not precise. No patient had a history of eye surgery.

Color vision tests were normal in all three children; none of them had color blindness, night blindness, cataracts, or glaucoma. No patient had either ptosis or lid tumor. No patient had scissor red reflex on retinoscopy examination or any evidence of keratoconus on slit-lamp eye examination.

According to a visual acuity of less than or equal to 20/60 in at least one eye, 9/2001 (0.4%) of children (including 3 cases with VI) had low vision. Table 3 summarizes the logMAR visual acuities of both eyes in the children who had low vision according to a visual acuity of less than or equal to 20/60 in at least one eye. Six patients were male, and three were female. Their mean age was 9.67 (SD = 1.73). Five patients were from educational district 2, three from educational district 3, and one from district 4.

The number of children in the family was one in two patients, two in four children, three in two children, and four in one case. Four out of nine of the children were the first child of their family; four out of nine were the second child, and one was the fourth child. Four out of nine patients (44%) with low vision had a history of consanguineous marriage. The fathers of 5 (55%) patients had no education. The mothers of 4 (44%) patients also had no education. The father's occupation was a worker in three cases, a businessman in four cases, and a government employee in two cases. The mothers of eight patients were housekeepers, and one patient's mother was a government employee (clerk). One of them had a history of premature birth without any evidence of retinopathy of prematurity. Two patients had asthma, and one patient had a history of seizure disorder using topiramate tablets. One patient had G6PD deficiency. None of the patients had a history of heart diseases, renal disorders, allergy, diabetes, hematologic disorders, or malignancy. None of these patients had a history of eye trauma. Eight out of nine patients (88.9%) used to wear eyeglasses due to refractive errors. Two patients had a history of strabismus surgery.

**Table 3: The logMAR and decimal visual acuities of both eyes in children who had low vision according to a visual acuity of ≤20/60 in at least one eye**

| Patients | OS_logMAR | OD_logMAR |
|---|---|---|
| 1 | 1 (0.1) | 0.8 (0.2) |
| 2 | 0.8 (0.2) | 0.8 (0.2) |
| 3 | 0.5 (0.3) | 0.5 (0.3) |
| 4 | 0.8 (0.2) | 0.1 (0.8) |
| 5 | 0.5 (0.3) | 0.3 (0.5) |
| 6 | 0.5 (0.3) | 0.2 (0.6) |
| 7 | 0.5 (0.3) | 0.1 (0.8) |
| 8 | 0 (10/10) | 0.5 (0.3) |
| 9 | 0.5 (0.3) | 0 (10/10) |

Color vision tests were normal in all these children; none of them had color blindness or night blindness. The stereopsis range was between 40 and 200 s of arc.

For the NPC, the range was between 5 and 15 cm with a mean of 7.42 (±3.40).

According to our assessment, three patients had VI (high ametropic amblyopia); of the remaining six patients, four had anisometropic amblyopia, one strabismic amblyopia, and one combined anisometropic and strabismic amblyopia. None of these patients had cataract or glaucoma. No patient had either ptosis or lid tumor.

Table 1 displays the descriptive statistics of these nine patients with low vision in at least one eye. No patient had scissor red reflex on retinoscopy examination or any evidence of keratoconus on slit-lamp eye examination. Cornea and lens were clear in all patients. Fundus examination demonstrated normal optic nerve and retina in all patients.

## Discussion

To delineate appropriate strategies to prevent and treat low vision and VI in children, the first step is to obtain epidemiologic data and determinants of pediatric low vision. It allows us to determine priorities in control of VI. In the present study, we demonstrated the prevalence of VI and low vision among schoolchildren aged 6–12 years from Shiraz between 2015 and 2016. The sampling method of this study and the selection of children from all four educational districts of Shiraz make it generalizable.

To the best of our knowledge, few studies have been performed in Iran to assess the prevalence of VI among school-aged children.[8,17-19] According to our results from a total of 2001 students who participated in the study, the prevalence of VI based on a visual acuity of 20/60 in the better eye was 3/2001 (0.14%). The mean age of the students was 9.1 ± 1.6 years, and 59.7% of them were girls. To facilitate comparisons between our findings with those of many other studies, we used the WHO criteria for classification of the VI in our study.

The mean global prevalence of VI is 3.4%.[20] The global prevalence of distance and/or near vision impairment for 1–14 years is 2.8%. The prevalence has been reported as 4.04% in Tehran.[7] The prevalence is 3.0% in Tunisia,[21] 5.8% in Indonesia,[22] 2.4% in Malaysia,[23] 1.8% in Italy,[24] and 0.4%

in Canada.[25] These studies have been performed on older adults. In a recent study by Abdolalizadeh *et al*., a retrospective analysis of data from the Global Burden of Disease 2017 was performed, and rates of vision impairment in three pediatric age groups of 1–4 (preschool children), 5–9 (schoolchildren), and 10–14 (teenagers) years were obtained and correlated with socioeconomic indices of 195 countries. According to this study, in 2017, the prevalence of distance and/or near vision impairment in children aged 1–14 years was 2.8% worldwide. 3.5% of teenagers had distance and/or near vision impairment, the highest prevalence among pediatric age groups, followed by schoolchildren (3.0%) and preschool children (2.0%).[26]

According to the study on the prevalence and causes of VI in Khuzestan Province, southwest of Iran, the rate of bilateral blindness and VI (BCVA <20/60) in subjects older than 5 years of age was 1.3% and 2.6%, respectively.[8] A significant positive trend ($P < 0.001$) was observed for blindness and low vision with increasing age. The most prevalent causes of VI in this study are cataracts (39.0%), refractive errors (37.9%), and amblyopia (23.6%).[8]

In the study performed by Yekta *et al*., the prevalence of VI in Shiraz schoolchildren was assessed. By the definition of visual acuity of 6/12 or worse in the better eye, the rates of VI based on UCVA (correctable VI [CVI]) and BCVA (non-CVI) were 6.46% and 0.0%, respectively.[27] In Dezful, a city in the southwest of Iran, these values were 3.8% and 0.3%, respectively.[18] To determine the prevalence and causes of VI in 7-year-old children in Iran, the authors conducted a study on first-grade students in the primary schools in eight cities.[17] Although the subjects of this study (7-year-old children) were different from ours (schoolchildren aged 6–12 years), it is worth comparing their results with those obtained in our study. The prevalence of VI according to a visual acuity of 6/18 in this study was 0.341%.[17] In the present study, the prevalence of VI was 3/2001 (0.14%). The prevalence of low vision according to a visual acuity of 6/18 in at least one eye was 1.34% in the mentioned study.[17] The prevalence of low vision in at least one eye in the present study was 9/2001 (0.4%). Higher prevalence rates have been reported among schoolchildren in China (27% and 0.46%, respectively), Malaysia (17.1% and 1.4%, respectively), New Delhi of India (6.4% and 0.81%), and South Africa (1.4% and 0.32%).[28-31]

The results of the present study are in line with those of a previous survey in Shiraz schoolchildren[27] and also the study in Dezful.[18] Therefore, our results, in addition to the previous study in Shiraz schoolchildren, indicate that the rate of VI is relatively lower compared to other cities of Iran and many other countries.

Several factors, including cultural, geographical, and social differences, might be involved in the different prevalence of VI from various countries. We attribute this valuable ratio to the incorporation of precise pediatric vision screening programs as part of our national agenda and the thorough strategies that have been implemented in this screening. A study performed by Chen *et al*. was conducted on mass pediatric screening practice patterns within a period of 10 years, and results were analyzed from 18 countries across 5 continents.[32] In this research, vision screening programs were divided into three categories: in Type I, only vision was assessed; in Type II, vision and ocular alignment or ocular health (including general observation, Hirschberg test, pupillary reflex, red reflex, stereo test, and questionnaire) were assessed; and in Type III, in addition to Type I and II examinations, the risk factors of amblyopia were assessed. It has been demonstrated that 44% (8 out of 18) of the countries have implemented Type I examinations only, and screening for the risk factors (Type III) has been applied in just three countries, including Iran, Canada, and the United States. It is worth mentioning that only 62% of the high-income countries applied a more comprehensive approach other than testing vision only.[32] We think applying such a strategy in mass pediatric vision screening programs in our country has resulted in a low prevalence of VI in our schoolchildren, as demonstrated in our study.[32,33]

Therefore, we suppose that the most important reason for the low prevalence of VI in school-aged children might be the undertaking of vision screening programs in the past three decades in Iran. Detecting visually impaired children, treating them, and sending those with severe low vision and blind children to specific schools (schools for the blind) have resulted in a low prevalence of VI among school-aged children.

According to our results, VI in all the three children was due to significant refractive errors and resultant amblyopia. In fact, all the three patients with VI had high ametropic amblyopia. From the remaining six patients with low vision, four had anisometropic amblyopia, and one of them had combined anisometropic and strabismic amblyopia.

Worldwide, refractive errors are one of the major causes of VI.[34] VI has been classified as two distinct entities and terms: CVI that is the VI which is fixable by refraction and non-CVI which is not correctable by refraction and is due to ocular or neurological disease. Globally, CVI is considered to be the primary form of VI.[35] According to the WHO, among all age, gender, and ethnic groups, uncorrected refractive errors such as myopia, hypermetropia, and astigmatism are the second leading cause of VI.[35] Even in the United States, it has been found that 66% of VI in White individuals and 57% of VI in Black individuals have been a result of uncorrected refractive error.[36] In addition, the most common underlying cause of uncorrected VI in Latinos in Los Angeles (75%) and Chinese Americans (70.3%) has been uncorrected refractive errors.[37,38] Globally, in most previous studies, refractive errors have been reported as the most common cause of VI in school-aged children.[39-43] In both developed and developing countries, it has also been reported that 12.8 million children aged between 5 and 15 years are affected by uncorrected refractive errors.[44]

According to the definition of amblyopia, all three visually impaired patients in our study had bilateral amblyopia due to high refractive error. The close relationship of bilateral

decreased visual acuity to refractive error has been previously reported, and amblyopia has been demonstrated to be a common cause of VI.[40,45-48] Unilateral amblyopia is commonly caused by strabismus and anisometropia, whereas bilateral amblyopia usually results from high bilateral refractive error. Other less common causes of unilateral or bilateral amblyopia include visual axis occlusion from congenital cataracts or congenital ptosis. In fact, all the three patients with VI had high ametropic amblyopia. Of the remaining six patients with low vision, four also had anisometropic amblyopia, one had combined anisometropic and strabismic amblyopia, and one patient had strabismic amblyopia. As strabismic amblyopia is usually detected earlier due to the manifest deviation of the eyes, it can be managed in a timely manner compared to ametropic and anisometropic amblyopia that may go undetected for a long time. Our three patients with VI had high hyperopia, myopia, and high myopic astigmatism. Bilateral ametropic amblyopia in the setting of very high hyperopia, myopia, and astigmatism has been described in several previous human studies.[49-52] Although the precise threshold at which myopia, hyperopia, or astigmatism begins to induce bilateral amblyopia is yet to be determined, according to the current guidelines, bilateral hyperopia of more than 5, bilateral astigmatism of more than 2.5, and bilateral myopia of more than −6 have been considered amblyopiogenic. In one of the patients, there was astigmatism of OD: +1.25 − 4.50 × 10 and OS: +0.75 − 3.75 × 170. In another patient compound, myopic astigmatism of OD: −6.25 − 4.00 × 10 and OS: −7.25 − 2.75 × 145 was present. A severity-dependent relationship in the association between astigmatism and bilateral amblyopia has been observed.[53]

In line with our results, the most common causes of VI in the study on 7-year-old children in Iran were refractive errors (81.8%) and amblyopia (14.5%). Astigmatism and hyperopia were the most common refractive errors leading to VI with a prevalence of 61% and 32%, respectively. Myopia was the cause in 28% of the cases.[17]

We did not have any blind child in our study from four districts of education. Children with bilateral blindness are usually registered in schools for the blind and do not generally enter ordinary schools. Many blind children with congenital and hereditary causes die within the 1st year of life.

It has been stated that the top three causes of childhood blindness in developed countries are cortical VI, retinopathy of prematurity, and optic nerve hypoplasia.[11] There is evidence that a significant increase in both cortical vision loss and retinopathy of prematurity in the past 10 years has occurred in the United States.[11] In developing countries, the leading cause has been reported to be corneal opacification caused by a combination of xerophthalmia, measles, and the use of traditional eye medicine.[11] None of these etiologies was demonstrated as the cause of VI in our study. We also did not detect any signs and symptoms of Vitamin A deficiency. Previous studies in Iran have also demonstrated that VI and blindness are no longer attributed to corneal disorders.[8,54,55]

One of the strengths of our study is that it was designed as a population-based study. Unlike the clinic-based or referral studies, population-based study is less likely to suffer from referral and selection biases. In addition, it permits our results to be generalized to other similar populations. Another strength is that it included schoolchildren from all four educational districts of Shiraz affiliated to the Ministry of Education. As there are some differences regarding culture and socioeconomic status in these four districts, this allows us to generalize the results. Systematic approach and comprehensive examination of all eligible students was another strength of this study.

One of the limitations of the present study was that schoolchildren were selected from urban areas. According to previous studies, the causes of VI in urban areas are not exactly the same as those in rural areas. In addition, students from special-needs schools, including blind children, were excluded from the study. Therefore, it might not be appropriate to generalize the results of our study to children who are living in rural areas and to students in special-needs schools. Another limitation of the study was that cycloplegic refraction was performed 20 min after the last application of cyclopentolate eye drops. As maximum cycloplegic effect of cyclopentolate is about 40 min, refraction after 20 min might induce some errors. However, because subjective refraction was performed, we think it is unlikely that final results have been influenced by it.

To summarize, the rate of VI and low vision was very low in schoolchildren in our study. However, we should do our best to improve their performance in school and their ability to communicate. As children grow and enter the school, their visual words expand. They spend more time in school and doing their assignments. Recent developments in digital technology have also increased schoolchildren's visual demands. In addition, today, children spend a more considerable amount of their spare time with digital media. Therefore, low vision and VI affect their education and learning.[56,57] Thus, we should advance our screening strategies to detect VI at an earlier age to treat reversible causes of low vision.

According to our results, refractive amblyopia is the leading cause of VI, and this disease has no detectable sign at gross examination. Many children, parents, and teachers are unaware of this problem, signifying the importance of a vision screening program and regular eye examinations. This is important as most problems can easily be managed by glasses or vision training via amblyopia treatment strategies at a low cost. Thus, the number of schoolchildren with avoidable vision problems and potential socioeconomic burden can be reduced. In addition, there is a need for education and improved awareness among the teaching staff and parents regarding vision problems in children.

It is cost-efficient to correct these vision problems as they influence and promote future education and learning, social interactions, employment, socioeconomic status, academic performance, and quality of life. Further studies in other parts

of our country are warranted to provide data for developing a better health policy.


### Financial support and sponsorship

Nil.


### Conflicts of interest

There are no conflicts of interest.

## References


1. Dandona L, Dandona R. What is the global burden of visual impairment? BMC Med 2006;4:6.
2. Pizzarello L, Abiose A, Ffytche T, Duerksen R, Thulasiraj R, Taylor H, *et al.* Vision 2020: The right to sight: A global initiative to eliminate avoidable blindness. Arch Ophthalmol 2004;122:615-20.
3. Resnikoff S, Pascolini D, Etya'ale D, Kocur I, Pararajasegaram R, Pokharel GP, *et al.* Global data on visual impairment in the year 2002. Bull World Health Organ 2004;82:844-51.
4. Tabbara KF. Blindness in the eastern Mediterranean countries. Br J Ophthalmol 2001;85:771-5.
5. Fotouhi A, Hashemi H, Mohammad K, Jalali KH, Tehran Eye Study. The prevalence and causes of visual impairment in Tehran: The Tehran Eye Study. Br J Ophthalmol 2004;88:740-5.
6. Shahriari HA, Izadi S, Rouhani MR, Ghasemzadeh F, Maleki AR. Prevalence and causes of visual impairment and blindness in Sistan-va-Baluchestan Province, Iran: Zahedan Eye Study. Br J Ophthalmol 2007;91:579-84.
7. Soori H, Ali JM, Nasrin R. Prevalence and causes of low vision and blindness in Tehran Province, Iran. J Pak Med Assoc 2011;61:544-9.
8. Feghhi M, Khataminia G, Ziaei H, Latifi M. Prevalence and causes of blindness and low vision in Khuzestan Province, Iran. J Ophthalmic Vis Res 2009;4:29-34.
9. Thylefors B. A global initiative for the elimination of avoidable blindness. Am J Ophthalmol 1998;125:90-3.
10. Thylefors B. A global initiative for the elimination of avoidable blindness. Community Eye Health 1998;11:1-3.
11. Steinkuller PG, Du L, Gilbert C, Foster A, Collins ML, Coats DK. Childhood blindness. J AAPOS 1999;3:26-32.
12. Kerby CE. Causes and prevention of blindness in children of school age. Sight Sav Rev 1952;22:22-31.
13. World Health Organization. Global Initiative for the Elimination of Avoidable Blindness. Geneva: WHO; 1997.
14. Gilbert C, Foster A. Childhood blindness in the context of vision 2020 – The right to sight. Bull World Health Organ 2001;79:227-32.
15. Talebnejad MR, Nowroozzadeh MH, Mahdaviazad H, Khalili MR, Masoumpour MB, Keshtkar M, *et al.* The shiraz pediatric eye study; a population based survey of school age children: rationale, design and baseline characteristics. J Ophthalmic Vis Res 2018;13:293-300.
16. ICD-10: International statistical classification of diseases and related health problems: tenth revision, 2nd ed." [Online]. Available: https://apps.who.int/iris/handle/10665/42980. [Last accessed on 2020 Sep 01].
17. Ghaderi S, Hashemi H, Jafarzadehpur E, Yekta A, Ostadimoghaddam H, Mirzajani A, *et al.* The prevalence and causes of visual impairment in seven-year-old children. Clin Exp Optom 2018;101:380-5.
18. Fotouhi A, Hashemi H, Khabazkhoob M, Mohammad K. The prevalence of refractive errors among schoolchildren in Dezful, Iran. Br J Ophthalmol 2007;91:287-92.
19. Rezvan F, Khabazkhoob M, Fotouhi A, Hashemi H, Ostadimoghaddam H, Heravian J, *et al.* Prevalence of refractive errors among school children in Northeastern Iran. Ophthalmic Physiol Opt 2012;32:25-30.
20. World Health Organization. Magnitude and cause of visual impairment. WHO Fact Sheet No. 282. Geneva: WHO. Available from: http://www.who.int/mediacentre/factsheets/fs282/en/; 2011. [Last accessed on 2011 Jul].
21. Ayed S, Négrel AD, Nabli M, Kamel N, Jebri AM, Siddhom M. Prevalence and causes of blindness in the Tunisian republic. Results of a national survey conducted in 1993. Tunisian team on the evaluation of blindness. Sante 1998;8:275-82.
22. Saw SM, Husain R, Gazzard GM, Koh D, Widjaja D, Tan DT. Causes of low vision and blindness in rural Indonesia. Br J Ophthalmol 2003;87:1075-8.
23. Zainal M, Ismail SM, Ropilah AR, Elias H, Arumugam G, Alias D, *et al.* Prevalence of blindness and low vision in Malaysian population: Results from the National eye survey 1996. Br J Ophthalmol 2002;86:951-6.
24. Cedrone C, Nucci C, Scuderi G, Ricci F, Cerulli A, Culasso F. Prevalence of blindness and low vision in an Italian population: A comparison with other European studies. Eye (Lond) 2006;20:661-7.
25. Maberley DA, Hollands H, Chuo J, Tam G, Konkal J, Roesch M, *et al.* The prevalence of low vision and blindness in Canada. Eye (Lond) 2006;20:341-6.
26. Abdolalizadeh P, Chaibakhsh S, Falavarjani KG. Global burden of paediatric vision impairment: A trend analysis from 1990 to 2017. Eye (Lond) 2021;35:2136-45.
27. Yekta A, Fotouhi A, Hashemi H, Dehghani C, Ostadimoghaddam H, Heravian J, *et al.* Prevalence of refractive errors among schoolchildren in Shiraz, Iran. Clin Exp Ophthalmol 2010;38:242-8.
28. He M, Huang W, Zheng Y, Huang L, Ellwein LB. Refractive error and visual impairment in school children in rural southern China. Ophthalmology 2007;114:374-82.
29. Goh PP, Abqariyah Y, Pokharel GP, Ellwein LB. Refractive error and visual impairment in school-age children in Gombak district, Malaysia. Ophthalmology 2005;112:678-85.
30. Murthy GV, Gupta SK, Ellwein LB, Muñoz SR, Pokharel GP, Sanga L, *et al.* Refractive error in children in an urban population in New Delhi. Invest Ophthalmol Vis Sci 2002;43:623-31.
31. Naidoo KS, Raghunandan A, Mashige KP, Govender P, Holden BA, Pokharel GP, *et al.* Refractive error and visual impairment in African children in South Africa. Invest Ophthalmol Vis Sci 2003;44:3764-70.
32. Chen AH, Abu Bakar NF, Arthur P. Comparison of the pediatric vision screening program in 18 countries across five continents. J Curr Ophthalmol 2019;31:357-65.
33. Rafiei M, Rivakani F, Torabi L, Alaeddini F, Safiri S. Community-based amblyopia screening program for early detection in Iran: A repeated cross-sectional study from 1996 to 2013. Public Health 2017;142:196-200.
34. Dandona L, Dandona R. Estimation of global visual impairment due to uncorrected refractive error. Bull World Health Organ 2008;86:B-C.
35. Resnikoff S, Pascolini D, Mariotti SP, Pokharel GP. Global magnitude of visual impairment caused by uncorrected refractive errors in 2004. Bull World Health Organ 2008;86:63-70.
36. Tielsch JM, Sommer A, Witt K, Katz J, Royall RM. Blindness and visual impairment in an American urban population. The Baltimore eye survey. Arch Ophthalmol 1990;108:286-90.
37. Varma R, Mohanty SA, Deneen J, Wu J, Azen SP, LALES Group. Burden and predictors of undetected eye disease in Mexican-Americans: The los angeles latino eye study. Med Care 2008;46:497-506.
38. Varma R, Kim JS, Burkemper BS, Wen G, Torres M, Hsu C, *et al.* Prevalence and causes of visual impairment and blindness in Chinese American adults: The chinese american eye study. JAMA Ophthalmol 2016;134:785-93.
39. Schneider J, Leeder SR, Gopinath B, Wang JJ, Mitchell P. Frequency, course, and impact of correctable visual impairment (uncorrected refractive error). Surv Ophthalmol 2010;55:539-60.
40. Robaei D, Huynh SC, Kifley A, Mitchell P. Correctable and non-correctable visual impairment in a population-based sample of 12-year-old Australian children. Am J Ophthalmol 2006;142:112-8.
41. Bourne RR, Stevens GA, White RA, Smith JL, Flaxman SR, Price H, *et al.* Causes of vision loss worldwide, 1990-2010: A systematic analysis. Lancet Glob Health 2013;1:e339-49.
42. Hashemi H, Rezvan F, Yekta A, Ostadimoghaddam H, Soroush S, Dadbin N, *et al.* The prevalence and causes of visaual impairment and blindness in a rural population in the North of Iran. Iran J Public Health 2015;44:855-64.
43. Sharma A, Congdon N, Patel M, Gilbert C. School-based approaches to the correction of refractive error in children. Surv Ophthalmol 2012;57:272-83.
44. Matsumura H, Hirai H. Prevalence of myopia and refractive

changes in students from 3 to 17 years of age. Surv Ophthalmol 1999;44 Suppl 1:S109-15.
45. Robaei D, Rose K, Ojaimi E, Kifley A, Huynh S, Mitchell P. Visual acuity and the causes of visual loss in a population-based sample of 6-year-old Australian children. Ophthalmology 2005;112:1275-82.
46. Multi-Ethnic Pediatric Eye Disease Study (MEPEDS) Group. Prevalence and causes of visual impairment in African-American and Hispanic preschool children: The multi-ethnic pediatric eye disease study. Ophthalmology 2009;116:1990-2000.e1.
47. Kessel L, Hougaard JL, Mortensen C, Jørgensen T, Lund-Andersen H, Larsen M. Visual acuity and refractive errors in a suburban danish population: Inter99 Eye Study. Acta Ophthalmol Scand 2004;82:19-24.
48. Wang JJ, Foran S, Mitchell P. Age-specific prevalence and causes of bilateral and unilateral visual impairment in older Australians: The blue mountains eye study. Clin Exp Ophthalmol 2000;28:268-73.
49. Fern KD. Visual acuity outcome in isometropic hyperopia. Optom Vis Sci 1989;66:649-58.
50. Edelman PM, Borchert MS. Visual outcome in high hypermetropia. J AAPOS 1997;1:147-50.
51. Klimek DL, Cruz OA, Scott WE, Davitt BV. Isoametropic amblyopia due to high hyperopia in children. J AAPOS 2004;8:310-3.
52. Ziylan S, Yabas O, Zorlutuna N, Serin D. Isoametropic amblyopia in highly hyperopic children. Acta Ophthalmol Scand 2007;85:111-3.
53. Borchert MS, Varma R, Cotter SA, Tarczy-Hornoch K, McKean-Cowdin R, Lin JH, *et al.* Risk factors for hyperopia and myopia in preschool children the multi-ethnic pediatric eye disease and Baltimore pediatric eye disease studies. Ophthalmology 2011;118:1966-73.
54. Rajavi Z, Katibeh M, Ziaei H, Fardesmaeilpour N, Sehat M, Ahmadieh H, *et al.* Rapid assessment of avoidable blindness in Iran. Ophthalmology 2011;118:1812-8.
55. Hashemi H, Khabazkhoob M, Emamian MH, Shariati M, Fotouhi A. Visual impairment in the 40-to 64-year-old population of Shahroud, Iran. Eye (Lond) 2012;26:1071-7.
56. Basch CE. Vision and the achievement gap among urban minority youth. J Sch Health 2011;81:599-605.
57. Narayanasamy S, Vincent SJ, Sampson GP, Wood JM. Visual demands in modern Australian primary school classrooms. Clin Exp Optom 2016;99:233-40.