

# Vision Outcomes of a Vision Screening Program among Schoolchildren in Zimba, Zambia

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## ABSTRACT

### BACKGROUND

Development of the visual cortex is complete at the age of 8 to 10 years old. Impairment of vision during childhood can hamper a child's intellectual and behavioural growth and impact future success. Particularly within the remote, rural regions of Zimba, Zambia, access to routine childhood eye checkups is limited due to factors such as lack of healthcare access, low financial resources to fund eyecare interventions, and remotely located eye clinics. Specifically, a school-mandated vision screening program may help bridge these potential barriers to eye care and reduce the incidence of unidentified vision impairment amongst schoolchildren. Further, the establishment of a vision screening program amongst school children shows great promise as an efficient and cost-effective method of detecting treatable visual impairment. The purpose of this study was to determine the prevalence of visual acuity impairment and external eye abnormalities in school-aged children in Zimba, Zambia.

### METHODS

Vision screening was performed in children 5 to 18 years old (grades kindergarten to grade 9) between July - August 2019. The vision screening program involved the assessment of visual acuity, pupil size, colour vision, and reading vision. An external eye examination of the eyelids, orbit, cornea, and iris was also performed. Screening failures were defined as any child presenting with a visual acuity of 20/40 or worse or  $\geq 2$ -line interocular difference between eyes. School children who failed an external eye examination of the eyelids, orbit, cornea, and/or iris were also referred to the eye clinic.

### RESULTS

Of 676 schoolchildren screened, a total of 3.70 % (25 / 676) schoolchildren did not pass the vision screening program and were referred to the local ophthalmology clinic for further assessment. 1.33 % (9 / 676) did not pass the vision screening criterion for visual acuity. 2.51 % (17 / 676) did not pass the vision screening criterion based on external eye examination. One student failed both the visual acuity and external eye exam. Mild vision impairment (visual acuity between 20 / 40 to 20 / 60) was the most common amongst schoolchildren, comprising 55.56 % (5 / 9) of visual acuity failures. Corneal/conjunctival scars were the most common external eye abnormalities amongst schoolchildren, comprising 47.06 % (8 / 17) of external eye exam failures.

### CONCLUSIONS

Our study is the first to report on visual acuity impairment and external eye abnormalities amongst schoolchildren in Zimba, Zambia. Compared to other regions around the world, a low percentage of schoolchildren failed the established vision screening program.

### KEYWORDS

Visual Acuity, Vision Screening, Schoolchildren, Zimba, Zambia

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#### How to Cite This Article:

Huang JJ, Huang JJ, Huang JM, et al. Vision outcomes of a vision screening program among schoolchildren in Zimba, Zambia. *J Evid Based Med Healthc* 2022;9(04):1-6.

Received: 25-Feb-2022;

Manuscript No. JEBMH-22-55596;

Editor assigned: 28-Feb-2022;

PreQC No. JEBMH-22-55596(PQ);

Reviewed: 04-Mar-2022;

QC No. JEBMH-22-55596;

Revised: 17-Mar-2022;

Manuscript No. JEBMH-22-55596(R);

Published: 30-Mar-2022;

DOI: 10.18410/jebmh/2022/02.

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## BACKGROUND

Refractive errors (myopia, hyperopia, astigmatism) are the most common eye problems seen in children worldwide, with prevalence continuing to increase.<sup>1,2</sup> Globally, uncorrected refractive errors pose a significant problem, affecting 12.8 million children aged 5 - 15 years old. China and south - east Asia report the highest prevalence, particularly in highly developed urban areas.<sup>3</sup> Lack of visual intervention can negatively impact the quality of life of the child. Academically, poor vision can be detrimental to learning within the classroom, thus decreasing academic performance.<sup>4</sup> For example, a study in Australia on children in grade 3 found that those who failed vision screening testing scored lower on national standardized tests for reading, grammar and punctuation, and spelling and numeracy compared to children who passed vision screening testing.<sup>5</sup> Vision impairment during years of growth can also negatively impact behavioral development, productivity, and social success in the future.<sup>6</sup> Therefore, increasing pediatric vision screening, especially in low-income and/or underserved regions where access to eye care is limited, is critical for reducing long-term visual impairment effects in children. The establishment of a vision screening program amongst school children shows great promise as an efficient and cost-effective method of detecting treatable visual impairment. Particularly within the remote, rural regions of Zimba, Zambia, vision screening within schools may help bridge potential barriers to care, including lack of healthcare access, low financial resources to fund eye care interventions, and insufficient education on the importance of seeking regular eye checkups.<sup>7,8</sup> Thus, a school-mandated vision screening program may improve access to care as well as reduce vision impairment amongst local school children. The purpose of this study is to estimate the prevalence of visual acuity impairment and external eye abnormalities in school-aged children in the region of Zimba, Zambia. This study aims to contribute novel data on vision impairment for this population.

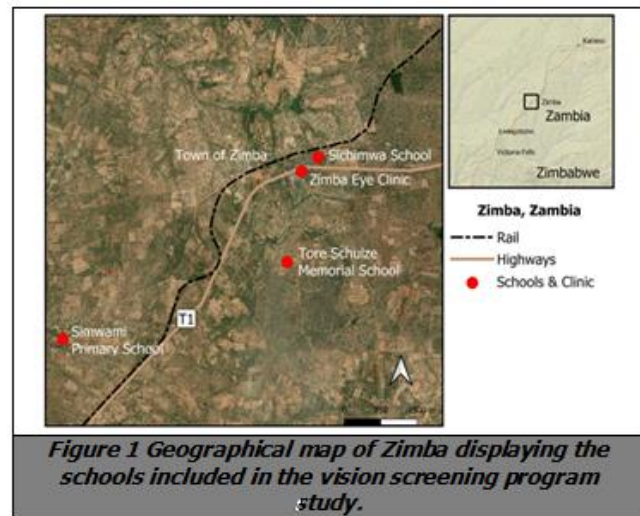
## METHODS

### Participant Characteristics

This study was approved by the ethics committee of the National Health Research Authority, Zambia. Ethical approval was also provided by the Government of Zambia and Minister of Health, in coordination with international vision volunteers (IVV) and international vision organization (IVO). All protocols adhered to the tenets of the Declaration of Helsinki. A total of 676 school children and teenagers, age 5 to 18 years of age (grades K to 9), from 3 schools in the Zambia region were included in the study. Age and sex data were collected prior to administration of a vision screening test. School locations were selected based on accessibility and proximity to the Zimba region (Figure 1).

### Vision Screening Program

Informed written consent was obtained from the parent or legal guardian of all participants. The screening team consisted of trained ophthalmic technologists, ophthalmic clinic staff and medical mission volunteers. Each team member was trained in vision screening and basic normal external eye examination. Participant data was collected over 16 days between July - August 2019. The screening team spent 1 - 4 days at each school. The vision screening program involved the assessment of visual acuity, pupil size,



colour vision, and reading vision. An external eye examination of the eyelids, orbit, cornea, and iris was also performed by a trained ophthalmic technologist. Visual acuity was assessed using a standardized Snellen or tumbling E chart test, depending on the language capability of the child. Both eyes were tested individually, followed by external anterior segment assessment. Pupil size was then measured. Using the Eye Handbook, a popular mobile app in eye care, colour vision and reading vision were assessed. All screening failures were referred to the Zimba Eye Clinic for complete eye examination by an ophthalmologist. Screening failures were defined as any child presenting with a visual acuity of 20 / 40 or worse or  $\geq 2$  - line interocular difference between eyes. Additionally, school children who failed a cursory external eye examination of the eyelids, orbit, cornea, and iris were referred to the eye clinic. Colour vision and pupil size data were not used in determining failure criteria.

### Classification of Distance Vision Impairment

The World Health Organization's (WHO) International Classification of Diseases 11 (2018) was used to classify distance vision impairment in this study.<sup>9</sup> Specifically, mild, moderate, and severe distance vision impairment were defined as schoolchildren presenting with a visual acuity worse than 20 / 40 to 20 / 60, 20 / 60 to 20 / 200, and 20 / 200 to 20 / 400, in the worse eye, respectively.<sup>9</sup> Blindness was defined as a visual acuity worse than 20 / 400, in the worse eye.<sup>9</sup>

## RESULTS

### Vision Screening

A total of 676 schoolchildren participated in the vision screening study. 52.2 % (353 / 676) of the participants were girls and 47.8 % (323 / 676) participants were boys (Figure 2). The mean age of participants was 10.9 years (range 5 to 18 years). Of the 676 schoolchildren screened, 3.70 % (25 / 676) of schoolchildren did not pass the vision screening program. Screening failure rates were highest amongst schoolchildren age 9 years, at 9.09 % (9 / 99), followed by age 14 years, at 6.25 % (4 / 64), and followed by 12 years, at 5.88 % (5 / 85) (Table 1).

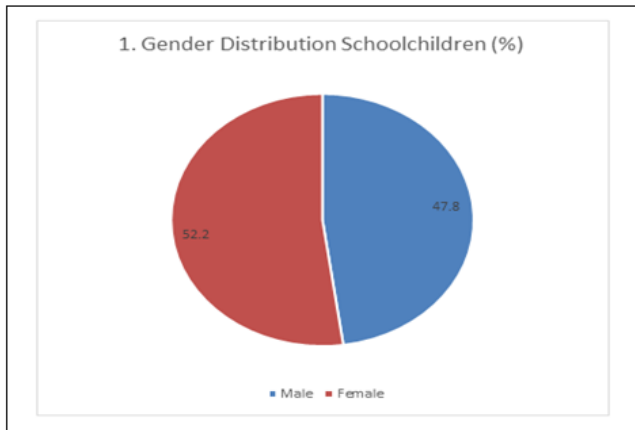


Figure 2 Gender distributions of schoolchildren in study.

Age/Age Range (years)	Distance Impairment Classification, No. (%)		
	Screened	Pass	Fail and Refer
5	3	3 (100.0)	0 (0)
6	1	1 (100.0)	0 (0)
7	65	65 (100.0)	0 (0)
8	74	72 (97.2)	2 (2.7)
9	76	75 (98.7)	1 (1.3)
10	99	90 (90.9)	9 (9.1)
11	72	70 (97.2)	2 (2.8)
12	85	80 (94.1)	5 (5.9)
13	72	71 (98.6)	1 (1.4)
14	64	60 (93.8)	4 (6.2)
15	37	36 (97.3)	1 (2.7)
16	25	25 (100)	0 (0)
17	1	1 (100)	0 (0)
18	2	2 (100)	0 (0)
Total (students)	676	651 (96.3)	25 (3.7)

Table 1 Vision Screening Test Results for Each Age Distribution of Schoolchildren.

**Visual Acuity Impairment**

Table 2 reports the prevalence of visual acuity impairment in each age group, categorized by severity. A total of 1.33 % (9 / 676) schoolchildren did not pass vision screening based on visual acuity. Mild visual acuity impairment (VA 20 / 40-20 / 60) was the most common, comprising 55.56 % (5 / 9) of screening failures. 22.22 % (2 / 9) students had moderate vision impairment (VA 20 / 60 - 20 / 200), and 22.22 % (2/9) students were blind (VA > 20/400). 98.67 % (667/676) had normal visual acuity (VA < 20/40).

Age/ Age range (years)	Distance Visual Acuity Impairment, n. (%)				
	Normal (< 20/40)	Mild (20/40 to 20/60)	Moderate (20/60 to 20/200)	Severe (20/200 to 20/400)	Blind (>20/400)
5	1 (100.0)	0 (0)	0 (0)	0 (0)	0 (0)
6	3 (100.0)	0 (0)	0 (0)	0 (0)	0 (0)
7	65 (100.0)	0 (0)	0 (0)	0 (0)	0 (0)
8	72 (97.2)	1 (1.4)	0 (0)	0 (0)	1 (1.4)
9	76 (100)	0 (0)	0 (0)	0 (0)	0 (0)
10	96 (97.0)	2 (2.0)	0 (0)	0 (0)	1 (1.0)
11	72 (100.0)	0 (0)	0 (0)	0 (0)	0 (0)
12	83 (97.6)	1 (1.2)	1 (1.2)	0 (0)	0 (0)
13	71 (98.6)	0 (0)	1 (1.4)	0 (0)	0 (0)
14	63 (98.4)	1 (1.6)	0 (0)	0 (0)	0 (0)
15	37 (100)	0 (0)	0 (0)	0 (0)	0 (0)
16	25 (100)	0 (0)	0 (0)	0 (0)	0 (0)
17	1 (100)	0 (0)	0 (0)	0 (0)	0 (0)
18	2 (100)	0 (0)	0 (0)	0 (0)	0 (0)
Total (students)	667 (98.7)	5 (0.7)	2 (0.3)	0 (0)	2 (0.3)

Table 2 Visual Acuity Screening Test Results for Each Age Distribution of Schoolchildren based on the WHO International Classification of Diseases for Distance Visual Acuity Impairment.

**External Eye Exam**

Table 3 summarizes the prevalence of various external eye examination abnormalities amongst each age group of schoolchildren. A total of 2.51 % (17 / 676) of schoolchildren did not pass the vision screening program based on external eye examination. Corneal / conjunctival scar was the most common external eye abnormality, comprising 47.06 % (8 / 17) of screening failures. 1 case of cataract was present in a 8 year old (5.88 %, 1 / 17), 1 case of ptosis was present in a 9 year old (5.88 %, 1 / 17), 1 case of dermatochalasis was present in a 10 year old (5.88 %, 1 / 17), a facial lesion was present in a 10 year old (5.88 %, 1 / 17), 1 case of iris pigmentation was present in a 10 year old (5.88 %, 1 / 17), 1 case of conjunctival nevus was present in a 14 year old (5.88 %, 1 / 17), 1 case of iris nevus was present in a 10 year old (5.88 %, 1 / 17), 1 case of conjunctival hemorrhage was present in a 12 year old (5.88 %, 1 / 17), and 1 case of iris coloboma was present in a 14 year old (5.88 %, 1 / 17). All screening failures were referred to the ophthalmology clinic for further assessment. This allowed for a second evaluation and vision correction in participants. For visual acuity problems, eyeglasses were prescribed and provided to the child at no cost. For external eye problems appropriate care and treatment was provided.

Age (years)	External Eye Exam Findings, n. (%)										
	Cataract	Corneal/Conjunctival Scar	Ptosis	Dermatochalasis	Facial Lesion	Iris Pigmentation	Conjunctival Nevus	Iris Nevus	Conjunctival Hemorrhage	Iris Coloboma	Pterygium
5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	1 (1.4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

9	0 (0)	0 (0)	1 (1.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	0 (0)	2 (2.0)	0 (0)	1 (1.0)	1 (1.0)	1 (1.0)	0 (0)	1 (1.0)	0 (0)	0 (0)	0 (0)
11	0 (0)	2 (2.8)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	0 (0)	2 (2.4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1.2)	0 (0)	0 (0)
13	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	1 (1.6)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1.6)	0 (0)	0 (0)	1 (1.6)	0 (0)
15	0 (0)	1 (2.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total (students)	1 (0.1)	8 (1.2)	1 (0.1)	1(0.1)	1(0.1)	1(0.1)	1(0.1)	1(0.1)	1(0.1)	1(0.1)	0

**Table 3 External Eye Exam Screening Test Results for Each Age Distribution of Schoolchildren.**

### DISCUSSION

Few studies exist on the prevalence of decreased visual acuity and external eye abnormalities amongst school children. We present prevalence estimations for visual acuity impairment and external eye abnormalities amongst schoolchildren aged 5 to 18 years in Zimba, Zambia. Compared with published data on visual acuity impairment amongst schoolchildren from other regions around the world with similar screening programs, the prevalence of visual acuity impairment in our sample population was low. In a study by Peng et al., from Hainan, China on 31,524 children aged 6 to 15 years old, 23.0 % of children presented with an uncorrected visual acuity (UCVA) worse than 20 / 40 in the worse eye.<sup>10</sup> Hark et al., reported 22.1 % of children aged 5 to 13 years within Philadelphia, USA to have an UCVA worse than 20/40.<sup>11</sup> A study by White et al., on grade 3 children in Australia, found 19.3 % of children with UCVA worse than 20 / 40.<sup>5</sup> A study on children aged 5 to 17 in Boston, USA, found that 23.7 % of children had a UCVA worse than 20 / 40.<sup>12</sup> Amongst homeless children in Denver, aged 1 month to 19 years old, 25.2 % were found to have a UCVA worse than 20 / 35.<sup>13</sup> Interestingly, a study by Kotipalli et al., from Andhra Pradesh, India, on 2887 children aged 7 to 15 years old found that 5.2 % of children had an UCVA worse than 20/40.<sup>14</sup>

The epidemiological explanation for the differences in prevalence of visual acuity impairment in children from different geographical regions is unknown, but may be attributed to factors such as genetics, outdoor sunlight exposure, and environment. 25 myopia loci have been discovered using linkage analyses to date, the first locus identified for myopia being Myopia 1 (MYP1).<sup>15</sup> The interplay of these loci is still unknown; however, associations dependent on race have been reported.<sup>15</sup> Paluru et al., proposed an association between the MYP5 locus on chromosome 17q21 - q22 and autosomal dominant high myopia in a multigenerational English/Canadian family.<sup>16</sup> Conversely, the MYP11 locus on chromosome 4q22 - q27 has been proposed to be associated with autosomal dominant high myopia amongst those of Chinese descent.<sup>17</sup> Studies also suggest that increased outdoor sunlight exposure plays an important role in the prevention of visual acuity decline. A study by He et al., on 952 schoolchildren found that an additional 40-minute class of outdoor activities decreased the 3 - year cumulative incidence rate of myopia compared to control (no additional outdoor class). Specifically, they reported a cumulative incidence rate of myopia of 30.4 % in the intervention group and 39.5% in the control group.<sup>18</sup> Similarly, a study by Parssinen et al., on 240 myopic schoolchildren aged 8 to 13 years found that

age at baseline, parental myopia, myopic progression during the first post onset year, increased time spent reading or on close work, and less time on outdoor activities in childhood were associated with higher myopia during adulthood.<sup>19</sup> Thus, geographic regions with these proposed risk factors may report higher rates of visual acuity impairment.

On external eye exam, the most common abnormality found was corneal/conjunctival scar, with a prevalence of 1.2 % (8 / 676). Comparatively, a study in the Soloman Islands and Vanuatu reported a 7% incidence of corneal/conjunctival scar amongst children aged 10 to 14 years.<sup>20</sup> In southwestern Nigeria, a study on 1144 primary and secondary students found 0.3 % of students had corneal/conjunctival scars.<sup>21</sup> Lastly, a study in Tanzania on 1386 students ages 7 to 19 years reported 0.8 % had corneal scars.<sup>22</sup> The exact reason for the variability in corneal/conjunctival scars amongst different global regions is unknown. Our study also found one case of pediatric cataracts. A study by Rushood et al., on 671119 children aged 6 to 15 years in Khartoum State, Sudan reported a 0.04% prevalence of cataracts amongst schoolchildren.<sup>23</sup> The presence of cataracts amongst schoolchildren in Zambia was lower compared to children in Tanzania (0.22 %), Southwestern Nigeria (0.2 %), and Tibet (0.37 %).<sup>21,22,24</sup>

A limitation of our study was lack of a standardized testing room to perform the visual acuity and external eye examinations. Within Zimba, most school rooms did not have electricity and instead utilized sunlight in a partially open-air classroom layout. Light exposure within the classrooms varied during the visual acuity examinations. This could have impacted the ability of the participants to perform the eye chart examinations. Further, both the Snellen and tumbling E visual acuity tests were used to assess for visual acuity impairment, depending on the ability of the child. The use of two different visual acuity impairment tests may have impacted the reported visual acuities due to the varying difficulties of each test.

### CONCLUSIONS

This study is the first to report on visual acuity impairment and external eye abnormalities amongst schoolchildren in Zimba, Zambia. Of the schoolchildren screened, 3.7 % of schoolchildren failed our visual screening program. The most common external eye abnormality found was corneal/conjunctival scar (1.2 % of schoolchildren). Compared to similar vision screening programs in schoolchildren from other countries, a low percentage of schoolchildren failed the visual screening program. Despite a low failure rate, vision screening programs show great promise in providing a simple, low cost means of detecting



for visual abnormalities. Overall, these findings contribute useful data on the incidence of visual impairment amongst schoolchildren within Zimba, Zambia. The establishment of a vision screening program can help inform government policies within the region with the goal of identifying, treating, and ultimately reducing visual abnormalities in schoolchildren.

#### ACKNOWLEDGEMENT

The authors would like to extend our thanks to the principal, staff, and students at the participating schools for their permission and accommodation for this study. To the Zimba Eye Clinic staff, International Vision Volunteers, and International Vision Organization, we deeply appreciate your contributions to eye care within the Zimba region.

#### Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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