ORIGINAL ARTICLE

Extraordinarily Low Prevalence of Refractive Error and Visual Impairment in Primary and Secondary School Learners in Kabwe District, Zambia

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ABSTRACT

Objective: Kabwe District is largely an urban town in the Central Province of Zambia. We aimed to determine the prevalence of refractive errors and visual impairment in primary and secondary school learners in this District.

Method: A cross-sectional survey of 41 primary and secondary schools in Kabwe District. The examination included visual acuity (VA) testing, cycloplegic retinoscopy with subjective refinement if indicated, ocular motility testing and anterior segment and fundus examinations in visually impaired children.

Results: There was an estimated total of 32,971 learners who were eligible to participate of which 23,915 (72.5%) were enrolled into the survey. Of the 2,424 learners examined by the mobile ophthalmic team,418 were refracted representing 17.2 %. Of the 418 learners refracted, 359 were diagnosed with refractive errors and prescribed spectacles. The mean spherical equivalent in the right eyes was 0.57 diopter (D) (95% confidence interval [CI], 0.49 – 0.75), and the mean spherical equivalent in the left eyes was 0.59 (95% CI, 0.50 – 0.71).The prevalence of hyperopia was 0.9% (95%

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CI, 0.4 – 1.3; 207 subjects), and the prevalence of myopia was 0.5% (95% CI, 0.1–1.0; 119 subjects). The majority of learners (98.3%; 95% CI, 97.0 –99.0) had normal unaided binocular VA (at least 6/9 in their better eye). The overall prevalence of any visual impairment (presenting VA 6/9 in the better eye) was 1.7% (95% CI, 1.0 –2.5; 418 subjects) and the overall refractive error prevalence was 1.5% (95% CI, 1.0 –2.3; 359 subjects). In multivariate logistic regression analysis, age (*P* 0.001) was a significant predictor and female gender (*P* 0.06) was a borderline significant predictor of the presence of any visual impairment.

Conclusions: Visual impairment is not a public health concern in this school–aged population in Kabwe District. The prevalence of uncorrected significant refractive errors among learners is not too high to justify a regular school eye screening programme in schools in Kabwe District.

INTRODUCTION

Uncorrected refractive error (URE) is the leading cause of vision impairment (VI), and the second leading cause of blindness worldwide.[1,2] This is more so especially in school going children.[3,4] Various studies report wide variations in the prevalence of myopia among different populations and ethnic groups.[5,6] The prevalence of myopia in certain regions such as East Asian regions, is high.[7] Myopia has dramatically increased in certain urbanized Asian regions, such as Singapore[8] and Taiwan,[9] but not in Australia,[10] and only weakly in the United States.[11]

Various hypotheses currently attempt to explain the wide variation in school-age myopia prevalence, including near work during childhood,[12–14] outdoor activity,[15–17] urban versus rural living,[4,18] and population density.[19] Myopia has been reported to affect approximately 37% of 13-year-old children living in rural southern China.[20] A study in Kafue District of Zambia showed the prevalence of refractive errors at 3.3% of which myopia was 2.2%.[21,22] This was lower than what was reported in other parts of the world.

Zambia is a land-locked country in Southern Africa. Approximately 50% of the population remains below the poverty line. However, the country has one of the world's highest current rates of urbanization. She has 10 provinces namely Central, Copperbelt, Eastern, Luapula, Lusaka, Muchinga, Northern, Northwestern, Southern and Western Provinces. Kabwe town is the provincial headquarters for Central Province. At the time of the study, prevalence of refractive errors in learners (schoolchildren) in Kabwe District was unknown and the study was primarily motivated by public health interests. The local ophthalmologistand Vision Aid Overseas initiated the current study to obtain an understanding of the prevalence of refractive error in the District learners (schoolchildren). An understanding of the prevalence of refractive error in children in this district was important for the planning of evidence-based programme delivery and the allocation of limited health care resources. If childhood refractive error was prevalent it could potentially be relatively easily managed and if it were not prevalent then it would not be a public health issue.

Negrel et al[23] devised a standardized procedure, the Refractive Error Study in Children (RESC) protocol, for the collection of refractive error data in school-aged children, which was initially trialed in Kafue District in Zambia.[21,23]

Other sites where RESC-type studies have been undertaken include India;[24] Malaysia;[25] Guangzhou Province, China;[20] and South Africa.[26] In the current study, we aimed to determine the prevalence of refractive error and visual impairment in learners from Kabwe District using a combination of RESC standardized protocol and Ministry of Health (MoH) ophthalmic practice guidelines for Zambia.

MATERIALS AND METHODS

Study Design

The study was designed as a cross-sectional, school-based survey of refractive error and visual impairment in primary and secondary school learners in Kabwe District of Central Province in Zambia.

Zambia School System

Primary school is compulsory and free in Zambia and officially commences at age seven years, and consists of seven grades, from grade one to seven. Secondary school is largely compulsory and has five grades from eight to 12. Repetition of a grade, particularly grades seven, nine and 12 is common; thus the variation in the ages of children in certain grades.

Definitions

For comparability of the results with those of RESC studies, the following definitions for refractive error were used:

Myopia was defined as spherical equivalent (SE) of 0.5 diopters (D) or less. Children with myopia in one or both eyes were classified as myopic.

Hyperopia was defined as SE of 2.0 D or more. Children with hyperopia in one or both eyes were classified as hyperopic. Astigmatism was defined as cylindrical refraction of 0.75 D or more in at least one eye, recorded with a negative sign. Refractive error was defined as myopia, hyperopia or astigmatism in either eye.

Visual impairment was categorized according to the current World Health Organization definitions of visual impairment and was consistent with other RESC studies classified as Mild –visual acuity worse than 6/12 to 6/18; Moderate –visual acuity worse than 6/18 to 6/60; Severe –visual acuity worse than 6/60 to 3/60 and Blindness –visual acuity worse than 3/60.

Sample Selection

The sampling frame was all learners (schoolchildren) in selected primary and secondary schools in Kabwe District between September and November 2021. Fourty one out 151 schools were randomly selected for the study. A total of 32,971 learners were required.

All children attending school from the randomly selected schools during the study period were eligible to participate. From a list of the schools, simple random sampling without replacement by pseudorandom number generation was used to select 41 schools; second-stage random sampling was used to select classes from each school. The total number of eligible learners(schoolchildren) selected by this cluster sampling approach was estimated using school population information from the Ministry of Education.

The District Education Board Secretary (DEBS) and the head teachers of all the participating schools in Kabwe District were contacted and informed about the activity. Consent was obtained from them after a detailed explanation of the purpose, content and benefit of the survey. The initial screening was conducted by the teachers who were trained to screen learners based on the visual acuity (VA) scoring and grading. The teachers screened 23,915 learners from which the mobile ophthalmic team rescreened and examined 2,424 learners. The vision screening chart used by the teachers was tumbling E eye visual acuity chart. The chart had to be read at a distance of six metres in proper daylight illumination. All the sampled learners registered in these schools participated in the survey in the order their names appeared in the school register from primary to secondary schools. The ophthalmic nurses obtained detailed information from the children with regard to the age, sex, gender, class and history or presence of any eye problem; known or unknown. The ophthalmic team children were asked whether their parents were aware of their eye problems and if they had consulted any eye health care personnel.

Learners whose visual acuity was less than 6/9 in any eye were subjected to further ophthalmic review and refraction. Penlight examination of the anterior segment and fundoscopy (sometimes with pupillary dilatation using 2.5% phenylephrine mixed with 1% tropicamide) if necessary was conducted by the ophthalmologist.

Those whose visual acuity improved with pinhole were refracted. Refraction was done with cycloplegia. Significant refractive error was the symptomatic refractive error of 0.5 or more for hypermetropia and worse for myopia and both for astigmatism.

Data Collection

Examinations were performed by three teams, comprising oneophthalmologist and twoother ophthalmic personnel including either ophthalmic nurses or/and ophthalmic clinical officers or/and optometry technologist allvery experienced with childhood vision testing and refraction. All team members underwent training in the RESC protocol in combination with the MoH ophthalmic practice guidelines, equipment use, measurement methods, and data-collection forms. The examinations took place over a four-week period in October–November 2021 at stations set up in each school. The testing and examination protocol included visual acuity (VA) measurements, cycloplegic retinoscopy, subjective refraction, ocular motility, and cover testing. The VA was measured at six metresusing a Snellen's chart with tumbling-E optotypes. The children were requested to indicate the direction of the E optotype by pointing with their hand or by calling the direction. The children were carefully observed to ensure that they were not squinting (using a pinhole effect).

Cycloplegia was induced with two drops of cyclopentolate 1% administered five minutes apart to each eye. After 20 minutes, if a pupillary light reflex was still present, a third drop was administered. The light reflex and pupil dilation were checked after an additional 15 minutes. Dilating and light reflex status were re-corded between 40 and 60 minutes after the first drop. Cycloplegia was considered complete if the pupil dilated to 6 mm or greater and a light reflex was absent.

Cycloplegic refraction was performed by an experienced mobile ophthalmic teamsusing streak retinoscopy on all subjects and refined with subjective refraction on eyes with an uncorrected VA of 6/9.

An experienced observer performed a cover test at 0.5 and 4.0 m, using the corneal light reflex to quantify the degree of tropia. For quality assurance, every tenth child had his or her VA and refraction measured again by a second experienced independent examiner.

In keeping with other RESC studies and in combination with the MoHophthalmic practice guidelines, those eyes with an equivalent of logarithm of the minimum angle of resolution VA>6/9, were assigned a principal cause of visual impairment by the team ophthalmologist, based on the findings from the refraction, cover test, handheld slit-lamp, and indirect ophthalmoscopic examinations. The principal cause of visual impairment was categorized on World Health Organization datasheets.

Ethical clearance was obtained from Excellence in Research Ethics and Science (ERES) Converge. Permission to carry out the survey was also obtained from the Ministries of Education and Health. The purpose of this study was explained to the learners in their own language, and the information sheet was being translated into the local language the learners understood well.

This information was found in the participant's information sheet. Informed consent was obtained from the head teachers.

Data Analysis

A coding system was used to ensure the confidentiality of all learners' details, and ensuring all data was captured for each learner independently. All data were entered into a computer using the software SPSS statistical package version. All data were recorded on a standardized reporting form, and data were entered into an electronic database. The data were analyzed using a commercially available statistical package (SPSS version 24.0). The 95% confidence intervals (CIs) of the proportion estimates and the standard errors of the regression analyses coefficients were calculated taking into account the two-stage cluster survey design.

RESULTS

There was a total of 32,971 learners (schoolchildren) who were eligible to participate and a total number of 23,915 learners were screened from 41 schools in Kabwe District in all six zones. This coverage represented 72.5% of the targeted 32,971 learners. The majority of participating learners were females

accounting for 54% (n=12,908) and 46% (n=11,007) were males. The learners' age ranged from five to 24 years and the median age was 13 years. Most of the participants were aged 10-14 years (56.9%) followed by 5-9 years age group (31.0%), 15-19 years age group (12.0%) and then those aged 20-24 years (0.1%), Table 1. No data were recorded about the absentee learners.

Table 1: Distribution of learners screened by age group and sex, N=23,915

Age Group	Female	Male	Total	%
5-9	4,043	3,366	7,409	31%
10-14	7,469	6,141	13,610	56.9%
15-19	1,389	1,479	2,868	12%
20-24	7	21	28	0.1%
TOTAL	**12,908**	**11,007**	**23,915**	**100%**

Out of 23,915 learners who were screened by the teachers, 2,727 were referred for further screening and examination by the mobile ophthalmic team. However, 2,424 learners came forward for screening by the mobile ophthalmic team, which resulted in a retention of 88.9% learners screened by mobile ophthalmic team.

Of the 2,424 learners examined by the mobile ophthalmic team, 1,983 (81.8%) were found to have eye problems including refractive errors while 64 were referred for surgical intervention by an ophthalmologist at the University Teaching Hospitals – Eye Hospital, Table 2.

Table 2: Screening by Teachers and Eye Health Personnel, N=23,915

CHARACTERISTIC	NUMBER OF LEARNERS SCREENED BY TEACHERS	TOTAL NUMBER OF LEARNERS IDENTIFIED TO HAVE EYE PROBLEMS BY TEACHERS	TOTAL NUMBER OF LEARNERS EXAMINED BY THE MOBILE OPHTHALMIC TEAM	EYE PROBLEMS CONFIRMED BY THE MOBILE OPHTHALMIC TEAM	TOTAL NUMBER OF LEARNERS REFERRED TO THE OPHTHALMOLOGIST
Number of learners	23,915	2,727	2,424	1,983	64

Of the 23,915 learners screened, 418 (1.7%) were found to have visual impairment of which 359 (1.5%) had refractive errors, Table 3.

Table 3: Prevalence of Refractive Errors in Learners Surveyed in School Screening

CHARACTERISTIC	TOTAL NUMBER OF LEARNERS SCREENED	NUMBER OF LEARNERS WITH REFRACTIVE ERRORS	PREVALENCE
TOTAL NUMBER OF LEARNERS SCREENED	23,915	359	1.5
SEX			
Male	11,007	135	0.6
Female	12,908	224	0.9
AGE GROUPS IN YEARS			
	7,409	36	0.2
10 – 14	13,610	212	0.9
15 – 19	2,868	106	0.4
20 – 24	28	5	0.02
TYPES OF REFRACTIVE ERRORS			
Myopia		119	0.5
Hyperopia		207	0.9
Astigmatism		33	0.1

The 359 out of 1,983 learners who were diagnosed with eye conditions by the mobile ophthalmic team had refractive errors represented 18.1% of the learners. The other eye conditions accounted for 81.9% (1,624/1,983).

Refractive Error

Complete refraction was performed on 359 learners. The mean spherical equivalent (SE) in the right eyes was 0.57 D (95% CI, 0.49 – 0.75), and the mean SE in the left eyes was 0.59 (95% CI, 0.50 – 0.71). The concordance correlation coefficients for the VA measurements and the

cycloplegic refractions were high (0.91 and 0.93, respectively).

The overall prevalence of refractive error was 1.5% (95% CI, 1.0 – 2.3; 359learners). The overall prevalence of hyperopia was 0.9% (95% CI, 0.4 – 1.3; 207learners), hyperopia 0.9% (95% CI, 0.4 – 1.3; 207 learners), myopia 0.5% (95% CI, 0.1–1.0; 119learners) and astigmatism 0.1% (95% CI, 0.0 – 0.2; 33 learners). Gender was not a significant predictor of refractive errors (p=0.089), but female gender was a borderline predictor of visual impairment (p=0.06). Age was a significant predictor of refractive errors (p=0.001).

Visual Acuity

The majority of learners, 98.3% (23,497/23,915), had normal unaided binocular VA (at least 6/9 in their better eye); (98.3% [95% CI, 97–99]). No child presented with spectacles. The overall prevalence of any visual impairment (presenting VA 6/9 in the better eye) was 0.2% (95% CI, 0.0 – 0.6; 59 subjects).

Causes of Visual Impairment

The majority of visual impairment was caused by refractive error. Of the fivelearners with moderate visual impairment, three had cataracts and two had a glaucoma (Table 4). Five learners had blindness.

Table 4. Causes of Visual Impairment

	Uncorrected VA of <6/9)	
Cause	*Right Eye*	*Left Eye*
Refractive error	359	350
Strabismus	9	8
Cataract	3	3
Blindness	4	5
Glaucoma	2	2
Other	8	12
Total	385	380
VA: visual acuity.		
*Presenting VA	6/9	

DISCUSSION

The most striking finding in this study was the exceptionally low prevalence of refractive errors especially myopia. The overall prevalence of refractive error was only 1.5% (95% CI, 1.0 – 2.3). A number of studies have performed refraction using both traditional cycloplegic retinoscopy and cycloplegic autorefraction.[24,26,27,28] The agreement between these two techniques by Bland–Altman plot analysis generally reported as "good," with 95% agreement approximately within 0.65 D in most studies.[24,26,27,28]However, auto-refraction has a tendency to minus over correction under non-cycloplegic conditions.[29]

Under cycloplegia, this tendency is largely neutralized, and clinically insignificant differences have been reported in population-based studies of Caucasian children.[26,27] However, a systematic tendency to more negative refraction has also been reported clinically[30] and in population-based studies of East Asian children.[25,31] Thus, in the current study, we have reported the cycloplegic retinoscopy results. The prevalence of myopia is considerably lower in western Asian region[28,32,33] and white Australian children,[34] and at its lowest in healthy indigenous Australian children.[35] A nationwide study conducted in Australia found that the prevalence of "low vision" (VA <6/9 but ≤ 6/60) in Australian aboriginal children aged five to 15 years was 1.5% (95% CI, 0.9 –2.1).[35] In this study, the prevalence of low vision was far lower than that in indigenous Australian children (0.2% [95% CI, 0.0 – 0.4]) and was also explained by the extremely low prevalence of myopia. The age range of the children in the current study was five to 24 years. The upper age limit is older than the typical five to 15-year age range reported in other studies; thus, we would have expected the overall prevalence of myopia and visual impairment to have been higher in the current study.

The prevalence of astigmatism in children of East and South Asian ancestry was reportedly greater than that of European Caucasian children.[36] However, the prevalence of corneal astigmatism (≤ 0.75 D) in the current study (0.1%; CI, 0.00–0.3) was far much lower than what was reported in

children of East Asian extraction.[25,37] The low prevalence of visual impairment in primary and secondary learners (schoolchildren) in Kabwe District is encouraging from a public health perspective, but the reasons for the exceptionally low prevalence of ametropia in this population need to be explored. During the data-collection phase of the study, it was clear that the educational facilities in Kabwe District were limited. The majority of schools had few or no books and most reading was from a blackboard. Although we did not attempt to collect data regarding the time children spent on near work/ reading or time spent outside, it seemed highly likely that these learners engaged in considerably less near work than similarly aged children from affluent, highly educated nations.

The initial RESC study design and accompanying studies were population-based,[24,26–28,37] but similar, large-scale, RESC-type studies have been school-based because of the greatly reduced cost and logistic difficulty compared with a population-based study of children.[34,37] The school-based design suffers the problem of selection bias.

Severely visually impaired children are unlikely to be attending school and may die at a preschool age. The study results can only be considered in the context of children within the schooling system. Furthermore, the results from this study can be extrapolated only to the Central Province and possibly other provincial headquarters. Although robust data regarding enrollment rates at school are lacking, considerable regional differences in childhood education are likely.

In conclusion, the current study provides the first robust evidence of the refractive error and visual impairment prevalence in primary and secondary school-aged children in Central Province of Zambia. Visual impairment is not a public health concern in this population. The exceptionally low prevalence of ametropia and visual impairment is consistent with current hypotheses regarding myopigenesis, but the precise underlying environmental and genetic influences driving myopia remain obscure.

RECOMMENDATIONS

Wide school screening is needed in various regions of Zambia to understand the exact pattern and magnitude of refractive errors among learners.

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