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Prevalence of refractive errors among schoolchildren in rural central Ethiopia

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Background: The aim of the present study was to assess the prevalence of refractive errors and visual impairment among schoolchildren in rural central Ethiopia.
Methods: A cross-sectional study was conducted from November 2010 to January 2011 among 5,470 schoolchildren from 14 schools, of whom 4,238 (aged 7–18 years) were screened for refractive errors. In all participants, uncorrected vision and best corrected visual acuity were determined and those with a visual acuity of 6/12 or worse, underwent a complete ophthalmic examination to determine the cause of visual impairment. Myopia was defined as a spherical equivalent of -0.50 dioptre (D) or greater in one or both eyes and hyperopia as a spherical equivalent of +2.00 D or greater. A cylindrical power of -0.50 DC (D cylinder) or greater was considered as astigmatism. Chi-square was used to test differences in proportions. Differences were considered to be statistically significant at the five per cent level.
Result: Of the 4,238 children, 405 (9.5 per cent) were visually impaired and of these 267 children were diagnosed as having refractive errors, with an overall prevalence of 6.3 per cent, comprised of 6.1 per cent in boys and 6.6 per cent in girls. Myopia is the most prevalent refractive error; accounting for 6.0 per cent, followed by compound myopic astigmatism 1.2 per cent, then simple myopic astigmatism 0.5 per cent, mixed astigmatism 0.26 per cent and finally hyperopia 0.33 per cent. Reasons for visual acuity of 6/12 or worse in the better eye were found to be refractive error (65.9 per cent), corneal problems (12.8 per cent) and amblyopia (9.6 per cent). The prevalence of manifest strabismus in the study group was 1.1 per cent (n = 45).
Conclusion: The study concluded that uncorrected refractive error is a common cause of visual impairment among schoolchildren in rural central Ethiopia. This indicates the need for regular school-screening programs that provide glasses at low cost or free of charge for those who have refractive errors.

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VISION 2020, the global initiative of the World Health Organization through the International Agency for the Prevention of Blindness for the elimination of avoidable blindness, recommends the control of refractive errors as a priority for national eye programs. One of the suggested strategies is to include a simple visual acuity (VA) test into school health programs with provision of spectacles to all children with significant refractive errors.[1] It affects a large proportion of the population worldwide, irrespective of age, sex and ethnic group. Undetected and uncorrected refractive errors are a particularly significant problem in school children. Poor vision and an inability to read material on the chalkboard due to refractive error can profoundly affect a child's participation, education, occupation and even socio-economic status for life.[2]

According to the 2006 National Survey Report in Ethiopia 11.4 per cent of blindness was due to uncorrected refractive errors.[3] In a study in Debark and Kola Diba towns, northern Ethiopia, the prevalence of visual impairment due to refractive errors in schoolchildren was 7.6 per cent.[4] In Ghana, visual impairment (VA of 6/12 or worse in the better eye) was present in 4.5 per cent of the children examined.[5] In a study conducted in India, 5.1 per cent of children in schools had VA of worse than 6/12 in the better eye.[6] In Uganda, significant refractive errors were detected among primary school children aged six to nine years at a prevalence of approximately 12 per cent.[7] The prevalence of refractive errors in school children in Tanzania, Riyadh and Nepal was 6.1, 4.5 and 8.6 per cent, respectively.[8–10]

The impact of blindness due to refractive errors is considered in terms of blind-person-years, a person becoming blind due to refractive error at a young age and which is not corrected, would suffer many more years of blindness than a person becoming blind from cataracts in old age and would place a greater socio-economic burden on society.[11]

Uncorrected refractive error is easily correctable by a pair of inexpensive spherical or/and cylindrical spectacles. The most accessible and acceptable way to correct visual disorder in children is to embed vision-testing programs in the schools to identify cases and to provide spectacles free-of-charge or at low cost.[12]

This study was conducted to assess the prevalence of refractive errors and to describe the causes of visual impairment among schoolchildren in rural central Ethiopia.

METHODS AND MATERIALS

Study area and sampling

A cross-sectional descriptive study of schoolchildren was carried out in rural central Ethiopia from November 2010 to January 2011. Meskan, Mareko, Sodo, Lanfuro, Silty and Dalocha are the six woredas (sub-districts), in which the study was conducted and are found in Gurage and Silti Zones of Southern Nations Nationalities Peoples Regional State (SNNPRS). There are 262 government schools in these six woredas, enrolling either grades 1 to 4 or 1 to 8. Fourteen schools (grades 1 to 8) were selected randomly from six sub-districts and all the students attending the randomly selected schools and present at the time of screening were included in the study (age range 7–18 years).

Ophthalmic examination

The students were examined in one room in the randomly selected school. VA was measured at a distance of six metres using the Snellen E chart. Children with presenting VA of 6/12 or worse underwent further ophthalmic examination, with non-cycloplegic objective (retinoscopy) and subjective refractions by the optometrist. Students presenting with organic ocular defects, such as amblyopia, corneal opacity, cataract and retinal disorders were recorded as 'other causes of visual impairment'.

Definitions and analysis

Myopia was defined as a spherical equivalent of -0.50 DS (dioptre sphere) or greater in one or both eyes. Hyperopia was defined as a spherical equivalent of +2.00 DS or more in one or both eyes. A cylindrical power of -0.50 DC (D cylinder) or greater was considered as astigmatism. Astigmatism was further analysed by dividing the subjects into five types: simple hyperopic astigmatism, compound hyperopic astigmatism, simple myopic astigmatism, compound myopic astigmatism and mixed astigmatism.

The results of the right eye were used to determine refractive errors. Data from the left eyes were taken for analysis whenever the right eye was affected by ocular pathology that hindered refraction. Presenting vision of 6/12 or worse in the better eye was considered as visual impairment and the prevalence data in this study are based on the better eye. Spectacles were distributed to children at their schools at a later date and vision was assessed in each eye at this time. Children failing to achieve the acuity measured at the time of the initial refraction were re-examined.

Measurement of visual improvement as reported and analysed in this paper is calculated based on the difference between the presenting and best corrected VAs, as measured at the time of the initial examination. The data were analysed using the Statistical Package for Social Science (SPSS) version 19 (SPSS Inc., Chicago, IL, USA). The prevalence of refractive errors among the screened students was estimated. Pearson's chi-squared test was applied and differences were considered significant at $p < 0.05$.

Ethical issues

The study protocol was approved by the Ethical Committee of the regional Health Bureau, Ethiopia. The school principals also approved the study. Written informed consent from a parent or guardian, in addition to the assent of each student was obtained before examination.

RESULT

Study population

A total of 5,470 children from 14 schools were potential subjects for the study, of whom 4,238 were screened for refractive errors and visual impairment. This gave a participation rate of 77 per cent. The non-responders included students who were absent on the day of the examination and those who did not consent to participate. All schools were government and mixed gender schools. The sample consisted of 2,272 males (53.6 per cent) and 1,966 females. The age of the students ranged from seven to 18 years. The mean age (and standard deviation [SD]) of participants was 13.07 ± 2.5 years. A total of 405 children (9.5 per cent) had unaided vision of 6/12 or worse in at least one eye (Table 1).

Vision and VA

Uncorrected vision of 6/9 or better in at least one eye was found in 3,833 students (90.5 per cent). A similar level was found in 4,066 (96 per cent) for the best corrected VA. Eighty-six students (2.0 per cent) had uncorrected vision of less than 6/60. Twenty-one students (0.4 per cent)

Gender	Students available	Screened	Visual acuity 6/12 or worse	Refractive error	Gender difference
			Number (%)	Number (%)	
Male	2,820	2,272	215 (9.5)	138 (6.1)	$\chi^2 = 0.21$ p = 0.07
Female	2,650	1,966	190 (9.7)	129 (6.6)	
Total	5,470	4,238	405 (9.5)	267 (6.3)	

Table 1. Distribution of students according to the overall results of vision screening, in rural central Ethiopia

had best corrected VAs of less than 6/60 in the better eye. The prevalence of visual impairment (VA of 6/12 or worse) was 9.6 per cent (405 of 4,238) in the better eye. Of the 11 students (0.26 per cent), who wore spectacles at the initial examination, seven (63.6 per cent) had presenting vision of 6/9 or better in at least one eye (Table 2). Uncorrected vision showed a statistically significant difference between genders ($p < 0.001$). Girls were more likely to have uncorrected vision of 6/12 or worse.

Of the 9.5 per cent of this sample found to have uncorrected vision of 6/12 or worse in the better eye, 6.3 per cent of the students examined (267 of 4,238) had refractive errors and the remaining 3.3 per cent (138 of 4,238) had a VA of 6/12 or worse due to corneal opacity, amblyopia, cataract or retinal problems (Table 3).

Refractive errors

The mean spherical equivalent for the sample was -4.20 ± 5.20 DS (range: -22.00 to +10.00 DS). In terms of gender, the mean spherical equivalent for males was -3.08 ± 4.35 DS (range: -20.00 DS to +10.00 DS), while that of females was -5.39 ± 5.77 DS (range: -22.00 DS to +2.75 DS). There was a statistical difference between the spherical equivalents for males and females ($p = 0.026$).

The prevalence of refractive errors was 6.3 per cent, with 6.1 per cent in boys and 6.6 per cent in girls. The overall rates of myopia and hyperopia in students 7–18 years were 6.0 and 0.33 per cent, respectively. Myopia increased from 1.1 per cent among children aged seven to nine years to 12.8 per cent in the age group 13–15 years, while the percentage of hyperopia was markedly decreased compared to that of myopia. This is presented separately in Table 4 for every year of age between seven and 18.

The second most frequent type of refractive error in our study was compound myopic astigmatism, which accounted for 1.2 per cent, followed by simple myopic astigmatism (0.56 per cent) (Table 5).

DISCUSSION

Refractive error is one of the avoidable causes of blindness and visual impairment. It can hinder education, personality development and career opportunities, in addition to causing an economic burden on society. So, it is essential to understand the pattern of refractive errors in school children to plan effective programs to deal with the problem. Provision of appropriate spectacles is one of the simplest, most cost-effective strategies to improve vision, yet uncorrected refractive error is the primary cause of moderate visual impairment throughout the world. In many countries, a shortage of eye-care specialists in rural areas may contribute to this problem.[13]

In general, in this study, uncorrected vision was found to be 6/12 or worse in 9.6 per cent of students, while a similar figure (9.4 per cent) was found for their presenting vision and in only 4.0 per cent was the VA at this level. These statistics show that the prevalence of visual impairment in this study (uncorrected vision of 6/12 or worse) was higher than results of studies done in Iran (3.8 per cent), Nepal (2.9 per cent), Ghana (4.5 per cent), rural areas in India (5.0 per cent), South Africa (2.7 per cent) and urban areas in India (9.0 per cent).[4,14–18] It was lower in comparison to results of studies in Egypt (22.1 per cent), Malaysia (17.1 per cent) and China (12.8 per cent). This difference may be partly due to the sampling methods.[19–21]

The prevalence of refractive error in our study (6.3 per cent) was similar to the 6.4 per cent in a North Indian study[21] but relatively lower than that found in Northern Ethiopia,[3] Nepal[10] and Uganda,[7] where the corresponding figures were 7.6, 8.6 and 12.0 per cent, respectively. In studies carried out in Iran,[14] India,[16] Riyadh[9] and Botswana,[22] the prevalence of refractive errors among school children was lower than the prevalence found in our study, namely, 3.8, 5.4, 5.0, 4.5 and 1.5 per cent, respectively. This finding could be due to different measurement cut-off points in the above studies and in our study and using different dioptric values to determine refractive errors. The age group and method of classifying refractive errors may account for the differences among these studies and there may be differences in genetic susceptibility to refractive errors that vary among different races.[23] In the present study, refractive errors were found to be more common in girls (6.6 per cent) than boys (6.1 per cent). This difference was marginally non-significant ($p = 0.07$).

Myopia (spherical equivalent refractive error of -0.5 DS or greater) in one or both eyes was found in 6.0 per cent of our subjects (253 of 4,238) and was higher than the study done in rural India[16] (4.1 per cent) but lower than the 7.4 per cent in Northern Ethiopia[3] and New Delhi,[18] the 6.8 per cent in Chile[24] and the 16.2 per cent in China.[25] This finding could be due to different environmental factors that may influence the occurrence and development of myopia, the definitions of myopia not being uniform and the

Category of vision	Unaided vision	Vision wearing glasses	Best corrected visual acuity
	Number (%)	Number (%)	Number (%)
6/6–6/9	3,833 (90.5)	7 (63.6)	4,066 (96)
6/12–6/18	237 (5.6)	3 (27.3)	110 (2.6)
6/24–6/60	82 (1.9)	1 (9.1)	41 (1.0)
< 6/60	86 (2.0)		21 (0.4)
Total	4,238 (100)	11 (100)	4,238 (100)

Table 2. Distribution of uncorrected vision, spectacle corrected vision and visual acuity in the better eye

Causes	Number (%) of eyes with visual impairment		Number (%) of students with visual impairment
	Right eye	Left eye	
Refractive error	245 (69.5)	233 (70.8)	267 (65.9)
Corneal opacity	47 (13.3)	34 (10.3)	52 (12.8)
Amblyopia	28 (7.9)	28 (8.5)	39 (9.6)
Cataract	12 (3.4)	15 (4.7)	17 (4.2)
Retinal condition	10 (2.8)	9 (2.7)	14 (3.5)
Other causes	4 (1.1)	5 (1.5)	7 (1.7)
Undefined causes	7 (2.0)	5 (1.5)	9 (2.2)
Total	353 (100)	329 (100)	405 (100)

Table 3. Causes of visual impairment in schoolchildren in rural central Ethiopia

	Type of refractive error. Number (%)		
Age (years)	Emmetropia	Myopia	Hyperopia
7–9	1,366 (98.8)	15 (1.1)	1 (0.07)
10–12	962 (90.7)	95 (8.9)	4 (0.37)
13–15	728 (86.4)	108 (12.8)	7 (0.83)
16–18	777 (95.4)	35 (4.3)	2 (0.3)
Total	3,833 (90.5)	253 (6.0)	14 (0.33)

Table 4. Distribution of refractive errors by age in rural central Ethiopia

refractions may have been performed with or without cycloplegia. In this study, myopia was common in children aged 10–12 years and 13–15 years and as age increases the number of children with myopia also increased.

The prevalence of hyperopia differs depending on the criteria used. In our study, hyperopia (spherical equivalent refractive error of +2.0 DS or more) in one or both eyes was found in 0.33 per cent of the studied population (14 of 4,238), which is similar to a study carried out in Northern Ethiopia.[3] It was lower than the 7.7 per cent in New Delhi,[18] 3.5 per cent in China,[25] 1.4 per cent in Nepal[15] and 0.8 per cent reported in rural India.[16] This difference is due to the inclusion of pre-school children in some of the above studies and a non-uniform definition of hyperopia.

Astigmatism of -0.50 DC or more in one or both eyes was present in 2.17 per cent of the study group. Simple myopic astigmatism was higher in males than females but the prevalence of compound myopic astigmatism was higher in females. The prevalence of astigmatism found in this study was comparable with the 2.5 per cent reported in Riyadh.[9]

The prevalence of spectacle use of 0.26 per cent is similar to the 0.58 per cent reported in rural India.[16] It is far less than the 30.3 per cent among students in Tanzania,[8] 42.3 per cent in Egypt[19] and 2.7 per cent in South Africa.[17] Social and economic factors are responsible for poor uptake of refractive services. In rural parts of Ethiopia, the wearing of spectacles is associated with blindness and individuals dislike the social stigmatisation associated with wearing glasses. The prevalence of manifest strabismus in this study was 1.1 per cent (n = 45), which is lower than the 7.4 per cent among students of 5–15 years in Haryana,[26] 0.5 per cent among children of 7–19 years in Tanzania[8] and 0.6 per cent in Delhi.[27]

CONCLUSION

This study concluded that uncorrected refractive error is a common cause of visual impairment among school children

Type of astigmatism	Gender		Total
	Male	Female	
	Number (%)	Number (%)	Number (%)
Simple myopic astigmatism	17 (0.41)	6 (0.14)	23 (0.56)
Simple hyperopic astigmatism	0 (0)	3 (0.07)	3 (0.07)
Compound myopic astigmatism	22 (0.54)	27 (0.66)	49 (1.2)
Compound hyperopic astigmatism	1 (0.02)	2 (0.05)	3 (0.07)
Mixed	6 (0.14)	5 (0.12)	11 (0.26)
Total	46 (1.12)	43 (1.05)	89 (2.17)

Table 5. Type and distribution of astigmatism by gender in rural central Ethiopia

in rural central Ethiopia. This indicates the need for a regular visual screening program for school children. This will facilitate identification of those with visual impairment, so that corrective measures may be suggested at the earliest time.

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REFERENCES

1. Global Initiative for the Elimination of Avoidable Blindness. Geneva, World Health Organization Action Plan 2006-2011. p 15–20. http://www.who.int/blindness/Vision2020_report.
2. Refractive errors: Magnitude of the need. *Community Eye Health* 2000; 13: 1–2.
3. Yemane B, Worku A, Bejiga A. National survey on blindness, low vision and trachoma in Ethiopia. *Ethiop J Health Dev* 2007; 21: 204–210.
4. Tibebu K, Getu D. Prevalence of refractive errors in pre -school and school children of Debark and Kola Diba towns, North-Western Ethiopia. *Ethiop J Health Dev* 2001; 17: 117–124.
5. Ovenseri-Ogbomo G, Assien R. Refractive error in school children in Agona Swedru, Ghana. *Afr Optom* 2010; 69: 86–92.
6. Kalikivayi V, Naduvilath TI, Bansal AK, Dandona L. Visual Impairment in school children in Southern India. *Ind J Ophthalmol* 1997; 45: 129–134.
7. Kawuma M, Mayeku R. A survey of the prevalence of refractive errors among children in lower primary schools in Kampala district. *Afr Health Sci* 2002; 2: 69–72.
8. Wedner SH, Ross DA, Todd J, Anemona A, Balira R, Foster A. Myopia in secondary school students in Mwanza City, Tanzania: The need for a national screening program. *Br J Ophthalmol* 2002; 86: 1200–1206.
9. Mohammad A. Prevalence of refractive errors among pre-school children at King Abdulaziz Medical City, Riyadh, Saudi Arabia. *Saudi J Ophthalmol* 2010; 24: 45–48.
10. Gauri S, Digen S, Purushottam J. Refractive error among school children in Jhapa. *Nepal J Optom* 2011; 4: 49–55.
11. Dandona R, Dandona L. Refractive error blindness. *Bull World Health Organ* 2001; 79: 237–243.
12. Resnikoff S, Pascolini D, Mariotti SP, Pokharel GP. Global magnitude of visual impairment caused by uncorrected refractive error in 2004. *Bull World Health Organ* 2008; 86: 63–70.
13. Pizzarello L, Abiose A, Ffytche T, Duerksen R, Thulasiraj R, Taylor H, Faal H et al. Vision 2020: the right to sight. A global initiative to eliminate avoidable blindness. *Arch Ophthalmol* 2004; 122: 615–620.
14. Fotouhi A, Hashemi H, Khabazkhoob M, Mohammad K. The prevalence of refractive errors among schoolchildren in Dezful, Iran. *Br J Ophthalmol* 2007; 91: 287–292.
15. Pokharel GP, Negrel AD, Munoz SR, Ellwein LB. Refractive error study in children: results from Mechi Zone, Nepal. *Am J Ophthalmol* 2000; 129: 436–444.
16. Dandona R, Dandona L, Srinivas M, Sahare P, Narsaiah S, Muñoz SR, Pokharel GP et al. Refractive errors in children in a rural population in India. *Invest Ophthalmol Vis Sci* 2002; 43: 615–622.
17. Naidoo KS, Raghunandan A, Mashige KP, Govender P, Holden BA, Pokharel GP, Ellwein LB. Refractive error and visual impairment in African children in South Africa. *Invest Ophthalmol Vis Sci* 2003; 44: 3764–3770.
18. Murthy GV, Gupta SK, Ellwein LB, Muñoz SR, Pokharel GP, Sanga L, Bachani D. Refractive error in children in an urban population in New Delhi. *Invest Ophthalmol Vis Sci* 2002; 43: 623–631.
19. Bayoumy B, Saad A, Choudhury A. Prevalence of refractive error and low vision among schoolchildren in Cairo. *East Mediterr Health J* 2007: 3: 575–579.
20. Goh P, Abqariyah Y, Pokharel GP, Ellwein LB. Refractive error and visual impairment in school-age children in Gombak District, Malaysia. *Ophthalmology* 2005; 112: 678–685.
21. Zhao J, Pan X, Sui RF, Muñoz SR, Sperduto RD, Ellwein LB. Refractive error study in children: results from Shunyi District, China. *Am J Ophthalmol* 2000; 129: 427–435.
22. Gilbert C. A pilot study to evaluate the methods and logistics for a prevalence and causes survey of visual impairment and hearing impairment in children. *J Commun Eye Health* 2000; 13: 3.
23. Robert N. Refractive error and ethnicity in children. *Arch Ophthalmol* 2003; 121: 1141–1147.
24. Maul E, Barroso S, M Muñoz SR, Sperduto SR, Ellwein LB. Refractive error study in children: results from La Florida, Chile. *Am J Ophthalmol* 2000; 129: 445–454.
25. He M, Zeng J, Liu Y, Xu J, Pokharel GP, Ellwein LB. Refractive error and visual impairment in urban children in southern china. *Invest Ophthalmol Vis Sci* 2004; 45: 793–799.
26. Naidoo KS, Raghunandan A, Mashige KP, Govender P, Holden BA, Pokharel GP, Ellwein LB. Refractive error and visual impairment in African children in South Africa. *Invest Ophthalmol Vis Sci.* 2003; 44: 3764–3770.
27. Khurana AK, Sikka KL, Parmar IPS, Aggawal SK. Ocular morbidity among school children in Rohtak city. *Indian J Public Health* 1984; 28: 217–220.