Original article

Prevalence of refractive errors in pre-school and school children of Debark and Kola Diba towns, North-western Ethiopia

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Abstract

Background: The problem of visual impairment among school children is so prevalent that it greatly reduces children's ability to study and attend classes and finally leads to the formation of grave social consequences. As it is seen from hospital reports, quite a considerable number of school children are suffering from some form of refractive errors, which could be easily corrected by the application of appropriate glasses.

Objectives: To determine the prevalence of visual impairment due to refractive errors in pre-school and school children aged 5 to 15 years in two towns of northwestern Ethiopia and, to investigate the influence of some factors on the problem of low vision due to refractive errors.

Design: The study was a cross-sectional survey.

Methods: One thousand one hundred thirty four pre-school and school children participated in the study. Level of visual acuity - visual acuity of <6/12 in either eye or both eyes was taken as a cut off level for low visual impairment and the three possible refractive states of the eye were studied. Other cut off levels were also considered for the sake of making comparisons with the findings of other similar studies.

Results: The prevalence rate of low visual impairment due to refractive errors was 7.6% and myopia was observed to be the most dominant state of refractive error (i.e., 98%), indicating a major visual problem in school children. Among the various influencing factors considered, age of child was found to be significantly associated with the presence of refractive errors (P<.003), while sex did not have such associations (P>.6).

Conclusions: Development of vision testing programs in schools and provision of lenses at a reduced cost for those with refractive errors and who cannot afford to buy the glasses are recommended. [*Ethiop.J.Health Dev.* 17(2):117-124]

Introduction

The normal condition of the eye, in which, with no accommodation, parallel light is focused on the retina is called emmetropia. Any optical departure from this condition is called a refractive error or ametropia. There are three kinds of refractive errors, namely myopia, hyperopia (also called hypermetropia) and astigmatism (1, 2). A refractive error is not considered as a disease, unless it is the magnification of a structural abnormality, as in some cases of high myopia and astigmatism. A refractive error can be classified as spherical or cylinderical according to the type of lens necessary to correct it (3).

A refractive error is determined by two factors:

I) The refractive power of the cornea and the lens

II) The length of the eye

These elements are usually correlated so that long eyes have less refractive power and short eyes have more refractive power, which

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minimizes any refractive error (4). In general, these types of errors can be easily corrected with glasses (2).

It is estimated that 2.3 billion people worldwide have refractive error. The vast majority of these could have their sight restored by spectacles, but only 1.8 billion people have access to eye examinations and affordable correction. This leaves approximately 500 million people, mostly in developing countries (close to 1/3 are in Africa) and many children, with uncorrected error causing blindness and impaired vision (5).

Undetected or under corrected refractive error, particularly myopia, is especially a problem in school children. Poor vision and the inability to read material written on the blackboard can have a serious impact on a child's participation and learning in class and this can adversely affect a child's education, occupation and socio-economic status for life (6). The prevalence of vision problems in children in the USA is estimated to be 5-10%. In a study in India, 5.1% of children in schools had a visual acuity of <6/12 in the better eye. In Botswana, a survey of children in schools and in the community showed that 1.5% of children aged 5-15 years had a visual acuity of < 6/18 in the better eye due to refractive errors (7). The problem is so prevalent that it does not only interfere with the children's ability to attend classes and study, but also creates grave social consequences. Teachers who do not realize the plight of the children, for example, accuse them of laziness or stupidity and humiliate them persistently. Unsympathetic classmates also pester them and laugh at them in the classrooms and as well as in playgrounds. Even their parents and siblings undermine and discourage these unfortunate children (6, 7, 8).

In spite of such grave consequences, however, there are few data available on the prevalence and types of refractive errors in children in developing countries (7). Likewise, the problem of low vision resulting from refractive errors has not been well studied in Ethiopia. Only very few studies which partially addressed the assessment of causes of blindness were carried out in the Southwestern part of the country (9).

The information gathered in the Gondar College of Medical Sciences (GCMS) Hospital in 1999, indicates that about 14% of the children (particularly, school children) who visited the Department of Ophthalmology were suffering from vision problems due to refractive errors (8). Those children who were discouraged because of vision impairment could quit classes and add to the number of the already considerable early school dropouts (8). Therefore, we strongly believe that the magnitude of the problem needs a systematic assessment. That, early assessment of vision of school children can facilitate correction of refractive errors of the victims. As indicated earlier, most refractive errors can be corrected with appropriate glasses (3). The purpose of the spectacle lens is to help focus the light rays on the retina (10). In addition to that, the finding that can be obtained will assist in enhancing social awareness and minimizing the misery of the children. Also, the corrective measure can help to encourage the children not to quit school. It is with these fundamental aims that this study was designed. Accordingly, the specific objectives of this study were;

1. To determine the prevalence of vision problem due to refractive errors
2. To find out the distribution of the possible refractive states in the study areas
3. To investigate the degree of association between selected variables (sex, age, educational status and geographical area) and the presence of refractive errors

Subjects and Methods

A cross sectional study to determine the prevalence of refractive errors among pre-school and school children was conducted in two small towns of Debark and Kola Diba, North-western Ethiopia between January and March 2000. Debark (population, 16,617), a highland area with an altitude of more than 2500 meters above sea level, is found at a distance of 100 kms. to the North of the City of

Gondar. On the other hand, Kola Diba, a lowland area below 2000 metres above sea level and with a population of 10,192, is located at a distance of 35 kms. to the South of this ancient city. The City of Gondar with a population, of above 150000 and known for its historical heritages is located in the North western part of Ethiopia, some 748 kms. away from Addis Ababa.

The study population consisted of pre-school (kindergarten) and school children aged 5 to 15 years and there were 5091 children who were eligible for our study, 2249 (44.2%) of whom were males. A simple random sampling technique was used to select the required sample size and a total of 1156 children were proposed to be included in our study. The list of children from the respective schools and kindergartens was used as a sampling frame. The sample size calculation was done on the basis of the following assumptions:

1) The proportion of school children with refractive errors was estimated to be about 14% (8).
2) The level of significance was taken as 5% (two-sided).
3) The tolerable error (absolute precision) was estimated to be 2%.

The usual formula of sample size calculation for a single proportion was applied in order to arrive at the above estimate. That is, $n = (1.96)^2 (.14x0.86) / (0.02)^2 = 1156$.

A questionnaire that was pre-tested on school children of a similar nearby area was used for collecting the most relevant data from the study subjects. The result of the eye examination of each study subject was also recorded. Two data collectors and two assistants were involved in each of the two urban centers for the initial phase of the eye examination and collection of relevant data. The Snellen chart was used to test the visual power of each child included in our study. The examination of the eye of each child was carried out using this Snellen chart at a conventional distance of six meters and a visual acuity of <6/12 in either eye or both was taken as a cut off point for vision impairment. In Ethiopia, a vision of 6/12 or better is required to hold a driver's license. However, in order to make comparisons with other similar studies, other visual cut off levels were also considered accordingly.

The data collectors were nurses by qualification and were recruited from the respective towns and from the Department of Nursing, GCMS. A two-day intensive training with practical examples was given for these data collectors and a reliability study was carried out before undertaking the actual data collection. Furthermore, in order to ensure the accuracy of data collected by the assigned nurses, a reliability study was undertaken on 114 (10% of the study subjects) children by an experienced Ophthalmologist and an Optometrist from the Department of Ophthalmology, GCMS. Only minor discrepancies which did not seriously affect the examination process were encountered. There were seven children all with visual acuity <6/12, but who were misclassified as 6/18 instead of 6/24 or vice versa.

Those children found with some visual problem have undergone through the second phase of the eye examination. An Ophthalmologist and an optometrist from the GCMS were responsible for the second phase of the eye examination and the type of refractive error was identified according to the refractive states of the eye (2, 10).

Myopia (short-sight) - The rays are focused in front of the retina and so they are blurred when they reach the retina, and the acuity is decreased. A concave (minus) lens in front of the eye helps to diverge the light to focus on the fovea.

Hyperopia (long-sight) - The rays are aiming towards a focus behind the retina and so they are blurred at the retina. The act of accommodation or the placing of a convex (plus) lens in front of the eye helps converge the light to focus on the fovea.

Astigmatism - Results when the curvature of some component of the optical system of the eye, for example the cornea, is not spherical but is toric. That is, the refracting surface is more curved in one meridian than in the meridian at 90 degree to it. Therefore, a point image of a point object is not possible. Astigmatism can be myopic, hyperopic, or mixed. This refractive state needs cylindrical lenses to correct the vision problem.

Furthermore, the type of lens that corrected the error was investigated and an appropriate prescription of spectacles was given to each child with some form of refractive error.

The investigators of the study thoroughly discussed the objectives of the survey with the officials of the respective district administrative council and school communities in order to facilitate data collection. Written consent was obtained from the respective administrative councils and verbal consent was obtained from each school/kindergarten involved in the study. Ethical clearance was also obtained from the Research and Publications Office of the GCMS. Data collection was very much facilitated as treatment was given free of charge for some active trachoma cases and the child with refractive error was given the prescription of the lens for correction of the visual defect according to the finding.

Data entry and analysis was carried out using the EPI-INFO version 6 and 2000 software programs. Statistical tests like Chi-square were used as appropriate and P-values less than 0.05 were considered significant.

Results

A total of 1134 (response rate 98.1%) pre-school and school children aged 5 to 15 were studied out of which 44.4% of them were males. The mean age of the study subjects was 10.5 years (median age 11 years), with a standard deviation of 2.7 years. The age structure of our study subjects had more or less a similar pattern with the total population of the eligible children considered in this study. The socio-demographic characteristics of the study subjects are depicted in table 1.

Table 1: **Socio-demographic characteristics of the study subjects in Debark and Kola Diba towns, North – western Ethiopia, January-March 2000.**

Variable	Frequency (n=1134)	Percent (%)
Age (Years)		
5-6 (pre-school age)	108	9.5
7-11 (early school age)	550	48.5
12-15 (late school age)	476	42.0
Sex		
Male	503	44.4
Female	631	55.6
Educational status		
Grade 0 (kindergarten)	108	9.5
Grade 1-3	382	33.7
Grade 4-6	347	30.6
Grade 7-8	297	26.2
Geographical Area		
Debark (highland)	567	50.0
Kola Diba (lowland)	567	50.0

According to the decision made earlier, vision test was carried out in each eye separately and 93 (8.2%) of the children had a visual acuity of <6/12 in either eye or both due to various reasons, such as, trachoma, refractive errors, etc. Among those subjects who had vision problems in either of their eyes or both, 84(90.3%, 84 out of 93) were myopic, 2(2.2%, 2 out of 93) were hyperopic. The remaining 7(7.5%, 7 out of 93) children had vision problems due other causes. No refractive states of astigmatism were identified in this study.

Overall, the prevalence of refractive errors resulting in some form of vision problem (i.e., visual acuity, <6/12) in either eye or both in our study subjects was 7.6%(i.e., 86 out of 1134). The results of the visual acuity tests performed on each individual are shown in table 2. As can be seen from this table, more than 30% of the children with some level of refractive errors had a serious visual impairment (6/36 and lower).

During the subsequent visits that followed the initial survey, children with vision problems due to refractive errors were identified and

Table 2: **Distribution of the study subjects by level of visual acuity in Debark and Kola Diba towns, North- western Ethiopia, January-March 2000.**

Level of visual acuity	Right eye only	Left eye only	Both eyes
6/4	51	44	748
6/6	43	49	162
6/12	19	20	34
6/18	13	11	19
6/24	8	13	9
6/36	5	4	14
6/60	6	4	3
Total	145	145	989

corrective measures were taken. The golden rule "give the minimum minus or the maximum plus which produces best vision", was applied on each individual with visual acuity <6/12 in either eye or both eyes. Each individual with vision problem was tested by putting up lenses into the trial frame until best acuity was achieved (6/6 or near to it) and finally an appropriate minus or plus lens was prescribed. Subsequently, about 30% of them (all were myopic) had a refractive error of -2 or less in either eye or both eyes. In this study, two hyperopic children were identified and their visual problems were corrected by spectacle lenses of +1D and +1.25 D. Details are given in table 3.

Table 3: **Distribution of children with refractive errors (<6/12) by type of lenses prescribed to correct the visual problems in Debark and Kola Diba towns, North-western Ethiopia, January-March 2000.**

Dioptre	Right eye only	Left eye only	Both eyes
0.0 to +/-1.0	20	21	7
+/-1.25 to – 2.0	18	18	23
-2.25 to – 3.0	4	4	8
-3.25 to – 4.0	2	0	2
-4.25 to – 5.0	0	2	0
< - 5	2	1	0
Total	46	46	40

N.B. The dioptres given above refer to concave (minus) glasses except for two individuals whose vision problem was corrected by convex (plus) lenses of +1 and +1.25 dioptres.

When the data were further investigated, 64 (5.6%) of the children had a visual acuity of <6/12 in the better eye and in 90.6% of those children, refractive errors were observed to be the cause of vision impairment (data not shown). Moreover, it was learned from our study that 2.6% of the children aged 5 to 15 years had a visual acuity of <6/18 in the better eye due to refractive errors, 63% (19 out of 30) of whom had a refractive error of less than -2.00 D.

A univariate analysis was employed to investigate the association of a number of variables with the presence of refractive errors (visual acuity <6/12). In this investigation, a total of 86 children with refractive errors and 1041 children with out refractive errors were considered. The remaining 7 children with vision problems due to other causes (other than refractive errors) were not included. Accordingly, as the age of children increased from 5 to 15 years, the risk of developing refractive errors was also observed to be higher and higher correspondingly with an increasing trend of odds ratio and the association was statistically significant (trend test, P<0.003). A higher level of education also showed a significant association with the presence of refractive errors (trend test, P = 0.003). However, differences in sex and geographical area (highland vs. lowland) did not show a significant association with the presence of refractive errors in our study of pre-school and school children.

Finally, the multivariate logistic regression, which allows to relate the log odds of the binary outcome variable to a set of explanatory variables, was applied. The outcome variable was the presence/absence of refractive error in each individual child. As in the previous analysis, a total of 86 children with refractive errors and 1041 children with out refractive errors were considered. All the explanatory variables used in the univariate analysis were included in the multivariate analysis.

Age of children, which showed a strong association in the previous univariate analysis, remained to be strongly associated with the presence/absence of refractive errors after controlling for the effect of confounders (p<0.04). On the other hand, level of education which showed a significant association in the univariate analysis, fell short of statistical significance in the multivariate analysis (P>0.2). Similarly, it was learned from the multivariate analysis that sex and geographical area did not show significant associations with the presence/absence of refractive errors (Table 4).

Table 4: **Influence of some socio-demographic variables on refractive errors in Debark and Kola Diba towns, North-western Ethiopia, January-March 2000.**

Variable	*Refractive Error Yes	No	Odds ratio	P-value
Age (yrs)				
5 – 6	4	103	1.00	<0.003
7 – 11	33	515	1.65	(trend test)
12 – 15	49	423	2.98	
Sex				
Male	40	460	1.10	>.6
Female	46	581		(χ^2 – test)
Educational Status				
Grade 0 (kindergarten)	4	103	1.00	
Grade 1 – 3	15	368	1.03	=0.003 (trend test)
Grade 4 – 6	42	302	3.58	
Grade 7 – 8	25	268	2.40	
Geographical Area				
Debark (high land)	36	529	0.7	=.11
Kola Diba (low land)	50	512		(χ^2-tests)

*= visual acuity <6.12 in either eye or both

Discussion

In this study, the prevalence rates of visual problems in general and vision problems due to refractive errors in particular, in pre-school and school children aged 5 to 15 years were found to be 8.2% and 7.6% respectively. This finding was more or less compatible with the results of some studies carried out in some areas of India and the USA (8). When the data were further investigated, 5.6% of the children were observed to have had a visual acuity of <6/12 in the better eye, and this figure was slightly greater than the finding of a study carried out in India. In a similar study, in India, 5.1% of children in schools had a visual acuity of <6/12 in the better eye (7, 11). The prevalence rate of refractive errors in the present study is lower than what was observed by Kassa (8) at the Department of Ophthalmology, GCMS. This could be due to the fact that the latter study was hospital based, while our study was school (community) based. It is to be recalled that individuals visiting the Ophthalmology Department are patients with problems related to the eye.

Because the operational definitions of low vision and refractive errors (myopia, hyperopia, etc.) are not uniform across studies, we have tried to incorporate visual acuity of <6/12 in either eye (or both) and in the better eye in order to calculate the corresponding prevalences. Likewise, for the purpose of making comparisons with other similar studies, visual acuity <6/18 in the better eye was also investigated. In this regard, our study showed that 2.6% of children had a visual acuity of <6/18 in the better eye due to refractive errors. This finding was greater than what was found in Botswana. A similar survey in Botswana showed that only 1.5% of the children aged 5 to 15 years had a visual acuity of <6/18 due to refractive errors (7, 12). This difference could be attributed to the variations in the underlying study populations. An equally important point is that, geographic variation could also be a possible explanation for such differences.

It is reported elsewhere that there are 3 possible refractive states and myopia is a common and important cause of visual impairment in school children, particularly, between the ages of 6 and 15(6, 13). The finding obtained in this regard in our study was in complete agreement with the above statement. About 98% of the children with refractive errors of <6/12 were myopic indicating that myopia was a prevalent visual problem in school children.

Although there are few data available on the prevalence, types and associated risk factors of refractive errors in children in developing countries to make comparisons, there is a general truth that as age increases from pre-school age to early adolescence, an increasing number of children who would manifest their myopia will be observed (7, 10). This fact was entirely supported by the finding of our study that children aged 12 to 15 years were about 3 times at a higher probability of manifesting their myopia than children aged 5 to 6 years. In short, as shown by the univariate and multivariate analyses, age of children was observed to have had an influence on the presence of refractive errors and the association was statistically significant. However, it should be noted that this significant association holds true within the range of the specified age groups (i.e., children with ages 5 to 15 years).

The level of education, which showed a significant association with the presence of refractive errors in the univariate analysis, did not show the same significance association in the multivariate analysis. This could probably be due to the fact that as age increased from 5 to 15 years, the level of education also increased correspondingly from grade 0 (kindergarten) to grade 8. Therefore, this significant association between education status and refractive errors in the univariate analysis could be as a result of the influence of age itself on refractive errors.

In this study, sex did not show a significant association with the presence of refractive errors indicating the fact that refractive anomalies were more or less uniformly distributed among pre-school and school children. This finding was in agreement with the result of a similar study carried out in Australia (6). The pronounced difference in sex composition observed in our study subjects was due to the imbalance of the two sexes in the population from which the sample was drawn. However, the sex distribution in our sample was more or less proportional to the sex distribution in the total population. The reason for the reduced number of male children in the underlying population, hence in our sample, could probably be due to the fact that some male children in these study areas might not be allowed to join schools for economic purposes. Boys usually assist their parents in looking after the cows and participate in other activities in such small towns, which are dominated largely by the surrounding rural villages.

The difference between the prevalence rates of refractive errors among children of Debark (6.4%) and Kola Diba (8.9%) towns was not statistically significant at the 0.05 level of significance. Although it appeared that there had been some geographic variation in the prevalence of refractive errors, it would be premature and difficult to reach a firm conclusion based on our data, which showed an association close to significance (table 4). However, the tendency that children living in the lowland areas of Kola Diba were at higher risk of developing refractive errors should be verified in other big studies, with similar operational definitions.

Finally, although there were some minor problems in the sampling procedure (incompleteness of the study subjects with non response rate of 1.9%), the findings of this study are, in most cases, in agreement with the results of other studies. Moreover, the reasons of these non-responding children for not participating in the present cross sectional survey were not related to our study.

Accordingly, based on the findings of the present study the following recommendations are forwarded: 1) Vision testing programmes in schools should be developed and children should be screened at least once during early adolescence. This could be organized and implemented by the nearby health centers after getting the necessary training from the responsible higher health institutions 2) Ways of providing lenses either free of charge or at a reduced cost should be considered for those children with refractive errors of <6/12 and who cannot afford to buy the glasses.

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