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RESEARCH PAPER

PREVALENCE OF REFRACTIVE ERRORS AMONG JUNIOR HIGH SCHOOL STUDENTS INTHE EJISU JUABEN MUNICIPALITY OF GHANA

***E. K. Nakua*[1], *E. Otupiri*[1], *E. Owusu-Dabo*[2, 3], *V. M. Dzomeku*[4], *K. Otu-Danquah*[5], and *M. Anderson*[6]**

[1]*School of Public Health, Department of Population, Family and Reproductive Health, KNUST, Kumasi.*
Corresponding author, email: emmanngh@gmail.com
[2]*School of Public Health, Department of Global and International Health, KNUST, Kumasi.*
[3]*Kumasi Collaborative Center for Research in Tropical Medicine*
[4]*College of Health Sciences, Faculty of Allied Health Sciences, Department of Nursing, KNUST, Kumasi*
[5]*School of Medical Sciences, Department of Community Health, Center for Disability and Rehabilitation Center, KNUST, Kumasi.*
[6]*School of Medical Sciences, Department of Community Health, KNUST, Kumasi.*

ABSTRACT

Among school children, uncorrected refractive errors have a considerable impact on their participation and learning in class. The aim of this study was to assess the prevalence of refractive error among students in the Ejisu-Juabeng Municipality of Ghana. A survey with multi-stage sampling was undertaken. We interviewed 504 students aged 12-17 years and examined them for refractive errors. The prevalence of refractive errors among those with and without refractive error was compared by means of the chi-square test. Logistic regression analysis using refractive error as the dependent variable and adjusting for risk factors were performed. The overall prevalence rate of refractive errors was 7.5%. Out of the number of children with refractive errors, 39.5% had astigmatism, 31.6% had hyperopia and 28.9% had myopia. The prevalence rate was significantly higher among urban compared with rural students. Astigmatic refractive errors consists of with–the–rule (WTR) astigmatism 66.7%, against–the–rule (ATR) astigmatism 26.7% and oblique astigmatism (OBL) 6.6%. WTR and ATR astigmatism were more common in females than males. Multivariate logistic regression models showed no substantial confounding effects between near work, sex, and residence, suggesting that each covariate has an independent association with refractive error. In conclusion, near work, sex and high parental education level are factors contributing to refractive errors. Children in urban areas are at higher risk compared with their rural counterparts. We suggest that an efficient pre-school vision examination must be made part of the admission policy of all schools in Ghana.

Keywords: *Prevalence, refractive error, students, visual impairment, Ejisu-Juaben Municipality*

INTRODUCTION

The Global Initiative for the elimination of avoidable blindness (VISION 2020),recognizes refractive errors as a preventable cause of blindness. One of the suggested strategies is to include a simple visual acuity (VA) test into school health programmes with provision of spectacles to all children with significant refractive errors (WHO, 1999). Visual impairment resulting from refractive errors remain a significant public health problem worldwide (Dandona and Dandona, 2001; Ajaiyeoba *et al*., 2005). Undetected and uncorrected refractive errors are a significant problem in school children.

Uncorrected refractive errors are a common occurrence in children and can have serious consequences, with considerable impact on children's participation and learning in class (Sherwin *et al*., 2011). This can adversely affect their education, occupation, socio – economic status and quality of life in the long run. For example, the World Health Organization suggests that uncorrected refractive errors are the main cause of visual impairment in children. It is estimated that, 19 million children are visually impaired worldwide, out of which 12million are as a result of uncorrected refractive errors, a condition that could be easily diagnosed and corrected (WHO, 2013). "The situation is of public health concern in children and adolescents due to the blind person years they consequently suffer". Refractive errors are known to account for twice as many blind–person–years compared with cataract, due to earlier age of onset. Thus, a person who becomes blind due to refractive error at a young age, suffers many more years of blindness than a person becoming blind from cataract in old age. This situation tends to place a greater socio -economic burden on society (Uduak and Udom, 2007; Resnikoff *et al*., 2008).

Visual impairment due to eye diseases is estimated to affect about 285 million people globally; 246 million of whom have low vision and 39 million are blind (Pascolini and Mariotti, 2011). Visual impairment (VA of 6/12 or worse in the better eye) prevalence among children estimated by Ovenseri-Ogbomo and Assien (2010), in Agona Swedru, Ghana was 4.5% of the children examined. A study in the Debark and Kola Diba towns of Ethiopia estimated the prevalence of visual impairment to be 7.6% (Mehari and Yimer, 2013). The prevalence of refractive errors in school children in Tanzania and Nepal was 6.1, 4.5 and 8.6% respectively (Wedner *et al*., 2002; Mohammad, 2010; and Gauri *et al*., 2011).

Risk factors for refractive errors include both genetic and environmental - a primary contributory environmental factor being the frequent performance of work requiring extensive use of close vision as exemplified in formal education. Extensive investigations in population-based studies have established these factors (Kempen *et al*., 2004; Vitale *et al*., 2008). Among these, education is identified as a strong and consistent risk factor for myopia. Time spent outdoors has been identified as a potential protective factor against myopia in children. The prevalence of refractive errors has revealed marked differences between ethnic groups, residence (urban or rural) and age (Rai *et al*., 2012).

Multifactorial intervention strategies have however demonstrated efficacy in the identification, diagnosis and correction of refractive errors in children and adolescents. This could easily be realized with appropriate refractive correction, such as spectacles, contact lenses or refractive surgery. The exact causes of refractive errors are still being studied, although genetic and environmental factors have been implicated in their development (Al-Nuaimi *et al*., 2010). The reasons why they remain uncorrected encompass factors such as lack of awareness and recognition of the problem, non-availability of and/or inability to afford refractive services, insufficient provision of affordable corrective lenses and cultural disincentives to compliance (Resnikoff *et al*., 2008).

The objectives of this study were to determine the prevalence, identify the types and patterns, as well as risk factors for refractive errors among junior high school children in the Ejisu-Juaben Municipality of Ghana.

MATERIALS AND METHODS

Study design and Setting

This was an analytical cross-sectional study in which Junior High School students were screened for refractive errors. The study was conducted from June to July 2012 in the Ejisu-Juaben Municipality.

The Ejisu-Juaben Municipality is one of the 30 administrative and political districts in the Ashanti region of Ghana. It stretches over an area of 637.2 km² constituting about 10% of the entire Ashanti region and with Ejisu as its capital. Currently, it has four urban settlements namely Ejisu, Juaben, Besease and Bonwire. The Municipality is located in the central part of the Ashanti and lies within latitude 1° 45" N and longitude 6° 15" W and 7° 00" W.

There are 77 Junior High Schools (JHS) in the Municipality and out of this figure, 56 are public and 21 are in private hands. The total enrolment of these schools is about 8000.

Inclusion criteria

Junior high school students (JHS 1 to 3) in public schools, aged 12 to 17 years whose parents had consented by signing a consent form and are residents of Ejisu-Juaben were recruited for the study.

Exclusion criteria

Children who were sick or absent or those who were on medication for some other ailment were excluded in the study. The study did not also include students in private schools.

Sampling and sample size

The sample size was estimated using the Kish and Leslie's formula with the expected prevalence of refractive errors of 15.8% (Saad and El-Bayounmy, 2007) and allowing for an error of 5% at 95% confidence interval. The estimated sample size was multiplied by a design effect of 2.5 to account for clustering. Therefore the required sample size for the study was 540 with 5% provision for non-response.

A multistage sampling technique was employed and representation in the clusters was a proportion to the number of children in the sampled clusters. A census list for all the Junior High Schools in the Ejisu-Juaben Municipality was obtained from the district education office. Firstly, the schools were grouped according to the classification of the area whether the school is situated rural or urban area. Two public schools each from urban (Juaben Anglican JHS and Ejisu M/A JHS,) and rural (Achinakrom Methodist JHS and Achiase M/A JHS) settings of the Ejisu-Juaben Municipality were selected using the lottery method.

Secondly, the number of students to recruit from each school was determined by the population proportional to size using the 2011 figures of enrolment in Junior High Schools in each of the two clusters.

Thirdly students aged between 12 and 17 years were recruited from each participating school. The class register was used, and systematic random sampling technique, with a sampling interval of 3 was performed.

Ethical Consideration

Each participating school was visited at least two weeks before the screening day, and permission to conduct the study sought from the headmaster/headmistress. Participant information leaflets was attached to the parental informed consent form and given to each of the students to be taken to their parents or guardians. Only children who returned duly signed consent forms, and were willing to take part in the exercise were recruited. Parents who required further explanation before consenting for their children to participate in the study were invited to the particular school of the ward on the screening day, for further education. Ethical approval was obtained from the Kwame Nkrumah University of Science and Technology's/Komfo Anokye Teaching Hospital Committee for Human Research, Publications and Ethics.

EYE EXAMINATION

The entry visual acuity (VA) was measured with the Snellen chart at a distance of 6m. Children who wore eyeglasses had their VA taken with and without their eyeglasses. Children who read 6/9 or worse were refracted. Those who read 6/6 or better had their VA fogged with a +1.00DS (measured again with a + 1.00 D) and VA reassessed.

Ocular health examination (including anterior and posterior segment examination) was performed for all the children using penlight and direct ophthalmoscopy. Retinoscopy was performed to objectively assess refractive errors. Static retinoscopy was employed and relaxation of accommodation was realized using a + 1.50 DS as the fogging lens. The use of fogging lenses (e.g., +1.50 D) and simultaneous retinoscopy of both eyes minimized the risk of unbalanced refraction. The final prescriptions with the best (corrected) VA were recorded.

Non-cycloplegic subjective refraction was carried out for all children. This procedure was chosen for determining the required refractive correction because it is based on the patient's actual acceptance of the prescription. To ensure that accommodation was relaxed, a + 1.50 D lens was used to fog the eye monocular during refraction. This protocol has been used by other studies in Nigeria and South Africa to study refractive errors in school children (Wedner *et al.*, 2002; Adegbehingbe *et al*., 2005; and Mabaso *et al*., 2006).

Definitions

Refractive error was assigned as the cause of the visual impairment if in the absence of any obvious pathology, vision improved to 6/6 or better with refraction. Hyperopia for the purpose of this study was defined as a spherical power of ≥+2.00DS in both eyes or in one eye (if the other eye is emmetropic). Myopia referred to a spherical power of ≤-0.50 DS in both eyes or in one eye (if the other eye was emmetropic) while astigmatism was defined as a cylindrical error of -0.50DS. Thus the mean refractive error measurement has been reported to be similar in both left and right eyes. Near work was defined as activities done by students, mainly being spending two (2) or more hours of reading and watching television after school.

Statistical analysis

The data forms were checked for accuracy and completeness in the field before data entry. Data collected were entered in Microsoft Access 2007. The characteristics of the study sample were summarized and compared in relation to their place of residence urban verses rural. Differences between the two categories in terms of socio-demographic and refractive characteristics were compared using the Chi-square or Fisher’s exact test as appropriate. The logistic regression model was fitted to estimate independent associations between refractive error and predictor variables using variables that were independently significant ($p \leq 0.05$) in univariable analysis. In the subsequent steps, variables that were not predictors were entered into the final model one at a time and retained as multivariable predictor using likelihood ratio test. A backward stepwise analysis was performed to identify the variables that were removed from the model. The most non-significant variables were considered first for removal. Lighting system and family history of blindness were not statistically significant in the multivariable and were excluded from the model. Even though age was not statistically significant in the model it was kept because of its importance. A significance level of 0.05 was considered with 95% confidence interval. Statistical analysis was performed using Stata 12.1 (StataCorp, College Station, TX).

RESULTS

Among the 540 students sampled, 6 students were absent on the day of examination and 34 students failed to return the informed consent. Thus the total number of students examined in the urban and rural schools was 504 accounting for a response rate of 93.3% as shown in Table 1. About 2.8% (14) of the students have ever had eye examination.

Refractive error was significantly higher among

Table 1: Demographic characteristics of respondents by residence

	Rural N=252(%)	Urban N=252(%)	Total N=504(%)
Age group			
12-14	127(50.4)	133(52.8)	260(51.6)
15-17	125(49.6)	119(47.2)	244(48.4)
Sex			
Male	128(50.8)	129(51.2)	257(51.0)
Female	124(49.2)	123(48.8)	247(49.0)
Educational level of Parents*			
Low level of Education	169(67.1)	127(50.4)	296(58.7)
Higher level of Education	83(32.9)	125(49.6)	208(41.3)
Previous Eye Examination			
Examined before	4(1.6)	10(4.0)	14(2.8)
Never examined	248(98.4)	242(96.0)	490(97.2)

**Low level of education-No formal education and primary to Junior High School, High level of education- at least Senior High School*

Table 2: Factors associated with refractive error

	Refractive Error		
Characteristics	**Yes N(%)**	**No N(%)**	**P-value**
Age group			0.007
12-14	27(10.7)	225(89.3)	
15-17	11(4.4)	241(95.6)	
Sex			0.03
Male	13(5.1)	244(94.9)	
Female	25(10.1)	222(89.9)	
Setting			0.22
Urban	16(6.2)	244(93.9)	
Rural	22(9.0)	222(91.0)	
Educational level of Parents*			0.004
Low level of Education	14(4.7)	282(95.3)	
Higher level of Education	24(11.5)	184(88.5)	
Family history of blindness	-		0.55**
Yes	4(9.5)	38(90.5)	
No	34(7.4)	428(92.6)	
Lighting System			0.15
Dim light	7(4.9)	137(95.4)	
Bright light	31(8.6)	329(91.4)	
Near Work			0.006
Near work < 2hrs	13(4.7)	266(95.3)	
Near work ≥ 2hrs	25(11.1)	200(88.9)	

***Fisher Exact Test*
**Low level of education-No formal education and primary to Junior High School, High level of education- at least Senior High School*

urban male students who spent more than two hours reading or watching television after school, and students whose parents were of higher education level. The overall prevalence of refractive error was 7.5% and was significantly higher among urban students compared with rural students (10.7% vs. 4.4%)(Table 2).

Prevalence of the various types of refractive errors

Out of the 38 students with refractive errors, 15 (39.5%) had astigmatism, 12 (31.6%) had hyperopia and 11 (28.9%) had myopia. The fraction of refractive errors among students in urban schools was 11/38 (Astigmatism), 7/38 (Hyperopia) and 9/38 while those in the rural school was 4/38, 5/38 and 2/38 for astigmatism, hyperopia and myopia respectively.

Astigmatism was the most prevalent refractive error, accounting for 39.5% of all errors. Myopia was more prevalent (1.6%) among the urban students than the rural residents (0.4%). Hyperopia was the most prevalent refractive error in the rural residents,41.7%.

Generally, all 3 refractive errors were more common among females, urban and older students. Similarly, refractive errors were also more prevalent among students who use bright lights, those who spent at least two hours reading or watching television after school as well as those whose parents were of higher education background (Table 3).

Types of astigmatism

Astigmatism was the most frequent refractive error, accounting for 39.5% of all errors. The astigmatic powers ranged from – 0.50D to – 2.50D for all eyes. Low astigmatism powers (i.e. – 0.50 and – 0.75) were the most common, accounting for 40% of all astigmatic powers.

Table 3: Distribution of refractive errors by demographic characteristics, near work and lighting system

Characteristics	Astigmatism N=15	Myopia N=11	Hyperopia N=12	Total
Age Group				
12-14	5	4	7	16
15-17	10	7	5	22
Residence:				
Urban	11	9	7	27
Rural	4	2	5	11
Sex				
Female	9	6	10	25
Male	6	5	2	13
Educational level of Parents*				
Low level of education	6	3	5	14
High level of education	9	8	7	24
Lighting System				
Dim light	4	2	1	7
Bright light	11	9	11	31
Near Work				
Near work < 2hrs	5	2	6	13
Near work ≥ 2hrs	10	9	6	25

**Low level of education-No formal education and primary to Junior High School, High level of education- at least Senior High School*

The commonest type of astigmatism was with – the – rule (WTR) astigmatism accounting for two-thirds of astigmatic errors (Table 4).

Risk factors for refractive errors

Table 5 shows the factors associated with refractive errors between student's refractive errors.

Univariable analysis shows that living in urban areas (OR=2.63, 95% CI 1.27, 5.42) being female (OR=2.11; 95% CI=1.04, 4.23), and spending at least two hours reading or watching television after school (OR=2.56; 95% CI 1.27, 5.12), as well as having parents of higher education background (OR=2.63; 95% CI=1.32, 5.21), more than doubled the odds of developing refractive error. The multivariate model shows four factors remained significantly associated with the odds of having refractive error.

Table 4: Distribution of the various types of astigmatism by gender

Type of Astigmatism	Female (%)	Male (%)	Total
WTR	6(40.0)	4(26.7)	10
ATR	3(20.0)	1(6.7)	4
OBL	0	1(6.7)	1
Total	9(60.0)	6(40.0)	15

DISCUSSION

The overall prevalence of refractive error was 7.5% and was significantly higher among urban students compared with rural students. Multivariable analyses identified sex of child, educa-

Table 5: Association between student's refractive error and the various risk factors

	Univariate Analysis		Multivariate Analysis	
Characteristics	OR (95% CI)	P-value	AOR (95% CI)	P-value
Residence				
Rural (**ref**)	1.00		1.00	
Urban	2.63(1.27, 5.42)	0.009*	2.21(1.05, 4.67)	0.04*
Sex				
Male **(ref**)	1.00		1.00	
Female	2.11(1.04, 4.23)	0.04*	2.27(1.11, 4.61)	0.02*
Age Group				
12-14 (**ref**)	1.00		1.00	
15-17	1.51(0.77, 2.95)	0.23	1.47(0.73, 2.92)	0.28
Education level of Parents				
Low level of Education (**ref**)	1.00		1.00	
Higher level of Education	2.63(1.32, 5.21)	0.006*	2.33(1.15, 4.73)	0.02*
Lighting System				
Dim light (**ref**)	1.00			
No dim light	1.84(0.79, 4.29)	0.16		
Near Work				
Near work < 2hrs (**ref**)	1.00		1.00	
Near work ≥ 2hrs	2.56(1.27, 5.12)	0.008*	2.32(1.14, 4.72)	0.02*
Family History of Blindness				
Yes (**ref**)	1.00			
No	0.75(0.25, 2.24)	0.61		

**P-value<0.05*

tion level of parents and near work as the most important factors significantly associated with increased odds of refractive errors while schooling in rural areas is associated with lower odds of refractive error.

Refractive error is known to be the main cause of vision impairment (Dandona *et al*., 2002). A study conducted by Cleg and 2002 Group of Trainee Ophthalmic nurses in four districts in Ghana, reported a refractive error prevalence rate of 3.1% while a population-based study in the Cape Coast Municipality of Ghana stated a prevalence of 25.6% (Ovenseri-Ogbomo and Omuemu, 2010). While a study conducted among school children aged 6 – 9 years in Kampala, Uganda, recorded a prevalence of 11.6% (Kawuma and Mayeku, 2002). These variations in prevalence rates may be due to differences in study samples, methodology and classification criteria among the various studies. For example, the study conducted in four districts of Ghana among the general population used different measurement, methodology and classification criteria compared with this study in Ejisu-Juaben.

Astigmatism emerged the most common refractive error, accounting for more than a third of all errors while myopia was the least common. The finding is consistent with studies conducted among school children in the Central Region of Ghana (Ovenseri-Ogbomo *et al*., 2010) and in the Kampala district of Uganda (Kawuma *et al*., 2002). In contrast, findings from Asian school children in Lahore, Pakistan (Ali *et al*., 2007) and Jhapa, Nepal (Pokharel *et al.,* 2000) revealed myopia as the dominant refractive error. Studies have shown that heredity is an important factor associated with juvenile myopia according to a longitudinal study that examined parental myopia, near work, school achievement and children's refractive error (Mutti *et al*., 2002). Even though there was no evidence in the study by Mutti *et al* to suggest that children inherit myopia or susceptibility to the effects of near work from their parents. The difference in distribution of refractive errors is naturally likely to be due to the different geographical situations, ethnic variation and the age bracket.

The prevalence of refractive errors was significantly higher among female students compared with their male counterparts. The multivariate analysis revealed a positive correlation between sex and refractive error. Previous studies conducted in other countries confirm the relationship between sex and refractive errors (Mabaso *et al*., 2006; Saad *et al*., 2007). Conversely, a study conducted among Nepalese children-found no sex difference (Pokharel *et al*., 2000). The higher prevalence of refractive error among females could be due to the fact that women's eyes have a shorter axial length and shallower anterior chamber depth than their male counterparts, and therefore predisposes them to hyperopia (Foster and Alsbirk, 1997).

This analysis shows a positive correlation between educational level of parents and refractive errors of their children. This finding is compatible with other studies where education attainment of the father has been established to be significantly associated with the refractive errors of his children (Murthy *et al*., 2002). In the present study, children in urban areas tended to have parents with higher levels of education compared with their rural counterparts. There was an increased odds of refractive error among students of parents who attained higher levels of education. Students from families with higher levels of education and probably higher socio-economic status may experience more pressure to study, leading to many hours of reading, which could in turn precipitate myopia.

A positive association was observed between the prevalence of refractive errors and hours of near work ($\geq$ 2 hours of reading and watching television after school) per day. Previous studies have also confirmed a significant correlation between refractive error prevalence and near work activity (Khader *et al*., 2009). Prolonged near work is thought to lead to myopia via the blurred retinal image that occurs during near focus. A biochemical process is initiated within the retina by this retinal blur, which in turn stimulates biochemical and structural changes in the sclera and choroid that lead to axial elongation (Fredrick, 2002). This mechanism could elucidate the relationship between prolonged near work and refractive error.

LIMITATIONS AND STRENGTHS OF STUDY

This study provides information about the prevalence of refractive error among Junior High School students in the Ejisu-Juaben Municipality of Ghana. It suggests the need for eye examination for students at the basic level of education since oculo-visual disorders are known to affect learning ability and performance in class. The study however has some limitations:, anon-cycloplegic examination was used to examine children instead of cycloplegic (which requires that 2 drops of 1% cyclopentolate, administered 5 minutes apart, with a third drop administered after 20 minutes), hence the full refractory statuses of students could not be assessed. Nevertheless, the validity of the study's results is unlikely to be affected by this issue. The technique has been used to examine refractive error in other studies.

CONCLUSION

Refractive error is a significant cause of visual impairment among school children. There is a low uptake of refractive error services among Junior High School students. This study is one of the very few that evaluates the patterns of refractive errors among students attending urban and rural schools. Preventing vision problems and maintaining healthy eyes for all children from birth through adulthood must become a public health priority in Ghana.

The risk of refractive errors was significantly higher in students attending urban schools than rural. More females than males had refractive errors. Refractive error was more prevalent in children whose parents had high level of education. A significant correlation of prevalence of refractive error and hours of near work per day was confirmed in the present study. Astigmatism was the dominant refractive error and myopia was the least common in this population.

It is recommended that efficient preschool vision examination be made compulsory and part of the admission policy of all the schools in Ghana. This will enable early identification of those with visual disability so that corrective measures may be recommended at the earliest time possible.

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