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EPIDEMIOLOGY | RESEARCH ARTICLE

Prevalence and distribution of uncorrected refractive error among school children in the Bongo District of Ghana

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To estimate the prevalence and distribution of uncorrected refractive error among school children in the Bongo District of Ghana. A descriptive cross-sectional study was conducted among 12–15-year-old children in eighteen public junior high schools in the Bongo District of Ghana. External and internal eye examinations were conducted while a non–cycloplegic refraction technique was used to determine refractive errors among the children. A total of 1,705 school children were recruited and examined for refractive errors. Their mean age ± SD was 14.1 ± 0.9 years. The prevalence of uncorrected refractive error was 1.8% (95% CI 1.2%—2.5%) with myopia (0.8%; 95% CI 0.5%—1.4%) being the most common, followed by astigmatism (0.6%; 95% CI 0.3%—1.1%) then hyperopia (0.4%; 95% CI 0.2%—0.8%). A multinomial logistic regression revealed that female students had about three times higher risk of having uncorrected refractive error as compared to males after adjusting for age which was statistically significant (ARR: 2.7; 95% CI 1.2-6.3; z = 2.3; *P* = .02). None of the children with refractive error had correction. Even though the prevalence of uncorrected refractive error in this study is lower than that reported in different parts of the country, none of the children with an error had correction. There is, therefore, the need for other studies to be conducted to further explore the cause of this as well as the varying prevalence of uncorrected refractive errors among children in the northern and southern parts of Ghana.

ABOUT THE AUTHOR

Dr. Frederick Asare is an Optometrist, a public health professional and a doctoral researcher at the school of Optometry and Vision Science, Ulster University, UK who has keen interest in refractive errors, childhood eye diseases and the use of psychophysical techniques in investigating visual performance of real-world tasks. His interest in childhood refractive errors, and Dr. Priya Morjaria's research in school eye health combined brought together this study. They believe it provides valuable data on the prevalence of uncorrected refractive errors amongst school children in a district in the Northern part of Ghana where there is a lack of data. Data from this study can be further explored by future studies that can inform public health approaches such as school eye health programmes targeted at alleviating problems associated with uncorrected refractive errors.

PUBLIC INTEREST STATEMENT

Refractive error is a type of vision problem where rays of light fail to focus on the retina, hence result in blurry vision. Despite the fact that correction/treatment of refractive error is simple, less expensive and straightforward, it remains the most common cause of visual impairment globally.

In Ghana, it is found to affect individuals across all ages. However, for the young person who lives with this problem, he/she tends to have many more blind-years in life if uncorrected. As such, several school screening programmes have been introduced to help identify those with the problem so that appropriate treatment would be given to them.

In this research, school children in public junior high schools within a district in the Northern part of Ghana were screened/examined and the proportion that was found to have this treatable problem was given a pair of spectacles for correction.

Subjects: Epidemiology; Children and Youth; Epidemiology; Ophthalmology

Keywords: Ghana; uncorrected refractive error; school; eye health; prevalence; Bongo District

1. Introduction

Vision is critical for daily activities and visual impairment (VI) at birth or during childhood can have devastating effect on the quality of life (QoL) of the child with effects often being life–long (Brown and Barrett, 2011). According to the World Report on Vision, at least 2.2 billion people have VI globally, of whom at least 1 billion have VI that could have been prevented or has yet to be addressed (World Health Organisation (WHO), 2019). Of this number, approximately 124 million have moderate to severe distance VI or blindness which is attributable to unaddressed refractive error (RE) (World Health Organisation (WHO), 2019). In children, VI due to uncorrected refractive error (URE) affects 12.8 million within the age group 5–15 years accounting for a prevalence of 0.96% with the highest prevalence reported in areas of south Asia, south–east Asia and China (Resnikoff et al., 2008). In India and China for instance, the proportion of VI due to URE is reported to be 82% (Murthy et al., 2002) and 97.1% (He et al., 2007), respectively, with incidence of myopia and high myopia increasing at an alarming rate in those regions and globally (Rudnicka et al., 2016). A report by Rudnicka et al. revealed that Asians have the highest prevalence of myopia reaching 80% by 18 years of age while black children in Africa have the lowest prevalence (Rudnicka et al., 2016). In Africa, URE is reported to affect about 0.5 million children aged 5–15 years representing a prevalence of 0.2% (Resnikoff et al., 2008). A systematic review on myopia in under-19-year-olds showed that the prevalence of myopia in black children in Africa at 10 years of age is 1.8% and rises to 5.5% at 15 years (Rudnicka et al., 2016). Even though this is a reported estimate of prevalence in African children, it is worth noting that data on prevalence of URE differ between regions and within countries in Africa.

In Ghana for instance, different studies have reported varying prevalence of URE ranging from 3.2% to 13.3% (Kumah et al., 2013; Ovenseri-Ogbomo & Assien, 2010; Ovenseri–Ogbomo & Omuemu, 2010) due to the different definitions and methodologies used, with most of them conducted in Southern Ghana and very little in Northern Ghana (Northern region, Upper East region and Upper West region). In a study conducted in Cape Coast on school children aged 5–19 years, URE was found to be the major cause of VI accounting for about 25.6% of all causes (Ovenseri–Ogbomo & Omuemu, 2010). Another in the Ashanti region which included private school children aged 12–15 years reported that the prevalence of uncorrected, presenting, and best visual acuity ((VA) of 6/12 or worse in the better eye) was 3.7%, 3.5% and 0.4%, respectively (Kumah et al., 2013). Nakua et al. on the othe hand, reported that the prevalence of RE among junior high school (JHS) students aged 12–17 years in the Ejisu Juaben municipality was 7.5% which was higher in urban students than their rural counterparts (Nakua et al., 2015). Considering the fact that all these studies were conducted in the southern part of Ghana, it was found imperative to conduct similar study in the northern part to provide data on the prevalence of URE among school children in that region.

This study thus seeks to estimate the prevalence and distribution of URE among school children in the Bongo district of Ghana in order to provide baseline data on URE in the northern part of the country which will aid further studies.

2. Materials and methods

2.1. Study design and setting

The study was a school-based descriptive cross-sectional study in the Bongo District of Ghana. Bongo district is one of the 13 districts within the Upper East region of Ghana with a population of 84,545 and Bongo as its capital. It shares boundaries with Burkina Faso to the north, Kassena-Nankana East to the west, Bolgatanga Municipal to the south west and Nabdam District to south east (Ghana Statistical

Service, 2014). From the 2010 population census, it was reported that there are 3 public and 2 private Senior High Schools (SHS), 47 public and 3 private JHS, 72 public and 4 private primary schools and 71 public and 4 private kindergartens (Ghana Statistical Service, 2014). However, at the time of the study, the statistical unit of the Ghana Education Service (GES) revealed that there were 56 public JHS within the district.

2.2. Sampling

A list of all 56 public JHS within the district was obtained from the district education office. Even though the schools are grouped into circuits with each constituting a cluster, for the purpose of the study, these schools were stratified according to the six sub-districts within the district. Three schools were randomly selected from each sub–district to provide the required sample size. All students aged 12–15 years within each randomly selected school were finally recruited into the study and examined. All children were classified as living in rural setting.

2.3. Sample size calculation

The sample size for the study was determined using the Kish and Leslie's formula

$$s = \frac{x^2 np(1-p)}{d^2(n-1) + x^2 p(1-p)}$$

where

s = required sample size, x^2 = the table value of chi-squared for 1 degree of freedom at the desired confidence level (3.841), n = the population size (5000), p = population proportion (assumed to be 0.50 since this would provide the maximum sample size), d = degree of accuracy expressed as a proportion (0.05). Based on these parametres, a sample size of 357 was calculated which was multiplied by a design effect of 2.5 to account for clustering. A non-response rate of 10% was then applied and the final sample size obtained was 982. However, a total of 1705 school children were examined.

2.4. Ethical consideration

Ethical approval for the study was obtained from both the Ethics Committee at the London School of Hygiene and Tropical Medicine and the Navrongo Health Research Centre Institutional Review Board in the Upper East Region of Ghana and adhered to the tenets of the Declaration of Helsinki. Permission was obtained from the district director of the education service and head teachers at each participating school. Parents provided consent for their children to be included in the study while assent was obtained from the children after a verbal explanation of the study was given to them.

2.5. Data collection procedure and examination

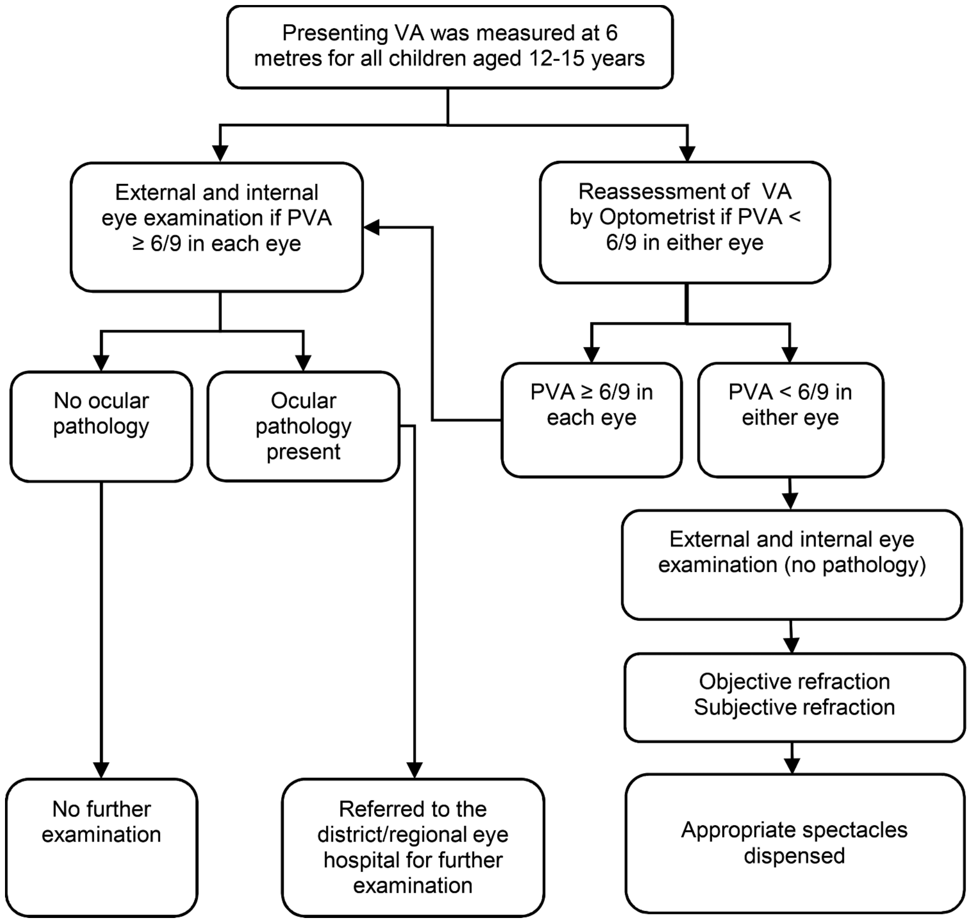
2.5.1. Pilot study

Before the actual data collection for the study began, a pilot study was conducted in one of the schools within the district after a two-day intensive training was given to the study team comprising trained nurses and data entry personnel. Visual acuity (VA) was assessed by the trained nurses and compared with that of the principal investigator (the optometrist) on the same students to check for reliability of the measured VA while data collection forms were completed by the data entry collection personnel to assess their validity in collecting data for the study. Any ambiguous item was then modified.

2.5.2. Data collection

Unique participant's identification (ID) was assigned to each student and demographic data which included age, gender, class, school name and location were collected. Ocular examination involved procedures like VA measurement, objective refraction, subjective refraction, and internal and external eye examination. Presenting visual acuity (PVA)—(that is with spectacle correction if usually worn) of each student was then measured by the trained nurses with the Snellen VA chart at 6 metres in the right eye and left eye respectively. Students who were unable to read the 6/9 optotype in either eye

Figure 1. A flow chart showing the data collection procedure used in the study.



were referred to the optometrist for reassessment of vision and refraction. Objective refraction with a retinoscope (Riester ri-scope RI.10543-slit HL, 2.5 V) in each eye, subjective refraction and best corrected VA (BCVA) in each eye were then measured. Children identified with RE were then given spectacles on the spot. External and internal eye examinations were further conducted with a head loupe and an ophthalmoscope (Welch Allyn REF, 11,710, NY, USA) to detect any other pathologies by the qualified and experienced optometrist. All pathologies were referred to the eye unit of the Bongo District Hospital and the regional eye hospital for further examination (Figure 1).

2.6. Definitions

For the purpose of the study, the following definitions which were adapted and modified from Morjaria et al. (2016) and Nakua et al. (2015) were used:

Uncorrected refractive error: PVA worse than 6/9 in either eye which improved with full correction by two or more lines in the better seeing eye.

Myopia: A spherical power of ≤ −0.50D in both eyes or in one eye (if the other eye was emmetropic).

Hyperopia: A spherical power of ≥ +1.00D in both eyes or in one eye (if the other eye is emmetropic).

Astigmatism: A cylindrical error of −0.50D.

<u>*Emmetropia*</u>: PVA better than or equal to 6/9 in each eye which reduced by 2 or more lines during the +1.00 blur test.

2.7. Data analysis

The data forms were analysed using STATA 15.1 (StataCorp, College Station, TX, USA) as frequencies, percentages, and proportions. Mean, standard deviations, prevalence and 95% confidence intervals (CI) were also estimated for quantitative variables with a significance level of 0.05 while a multinomial logistic regression was conducted to test the association between categorical variables. The results of the statistical analysis were then presented in the form of tables.

3. Results

3.1. Demographics

Out of the 1,817 school children who were enumerated for the study, 1,705 (94.0%) were examined and over half (55.4%) were females. The mean age ± standard deviation (SD) of the participants was 14.1 ± 0.9 years and their ages ranged from 12 to 15 years. A greater proportion (288) of the males were 15 years old, while majority of the females (355) examined were 14 years old. Table 1 illustrates the demographics of the participants.

Table 1. Age distribution of participants by gender

Characteristics	Male	Female	Total
Age (in years)	***n* (%)**	***n* (%)**	***n* (%)**
12	27 (1.6)	32 (1.9)	59 (3.5)
13	180 (10.6)	215 (12.6)	395 (23.2)
14	265 (15.4)	355 (20.8)	620 (36.4)
15	288 (16.9)	343 (20.1)	631 (37.0)
Total	760 (44.6)	945 (55.4)	1705 (100.0)

3.2. Visual status of participants

Of the children who underwent screening/examination, 30 had UREs representing a prevalence of 1.8% (95% CI 1.2%—2.5%) while 16 (0.9%; 95% CI 0.6%—1.5%) had other undetermined and ocular conditions including corneal opacity, cataract, macular scar, severe vernal keratoconjunctivitis, among others which caused a reduction in vision. The rest had emmetropia (PVA better than or equal to 6/9 in each eye) (Table 2). In ascertaining the relationship between visual status and gender of participants, a chi–square test was conducted which revealed a statistically significant association (X^2 = 5.94; df = 2; P = .05). A multinomial logistic regression analysis further revealed that females were about 3 times more likely to have UREs as compared to males after adjusting for age which was statistically significant (ARR: 2.7; 95% CI 1.2-6.3; z = 2.3; P = .02).

Table 2. Prevalence of the visual status of participants

Visual status	Male	Female	Total	Prevalence	95% CI
Emmetropia	747	912	1659	97.3	96.4–98.0
Myopia	4	10	14	0.8	0.5–1.4
Hyperopia	1	5	6	0.4	0.2–0.8
Astigmatism	2	8	10	0.6	0.3–1.1
Ocular pathology (Referred)	6	10	16	0.9	0.6–1.5

3.3. Distribution of URE by age and gender of participants

Myopia was the most common RE accounting for 46.7% (95% CI 30.2%—63.9%) followed by astigmatism, 33.3% (95% CI 19.1%—51.3%) with hyperopia being the least common which accounted for 20.0% (95% CI 9.1%—37.7%). However, none of the children with refractive error had a correction. Across all age groups, myopia was the most common type of RE except in the 12 year age group, where there was one case of astigmatism with no cases of myopia and hyperopia. The type of RE was, however, not dependent on the age of the child (X^2 = 6.79, df = 6, P = .34). Table 3 describes the distribution of REs by age.

Table 3. Distribution of refractive error by age

Characteristics	Myopia, *n* (%)	Hyperopia, *n* (%)	Astigmatism, *n* (%)	Total, *n* (%)
Age (in years)				
12	0 (0.0)	0 (0.0)	1 (3.3)	1 (3.3)
13	5 (16.7)	0 (0.0)	4 (13.3)	9 (30.0)
14	5 (16.7)	3 (10.0)	4 (13.3)	12 (40.0)
15	4 (13.3)	3 (10.0)	1 (3.3)	8 (26.7)
Total	14 (46.7)	6 (20.0)	10 (33.3)	30 (100.0)

4. Discussion

The results demonstrate that more females than males were examined which conforms to the male to female ratio within the district as reported in the 2010 Population and Housing Census (Ghana Statistical Service, 2014). Of the total number of children examined, majority of them were aged 14 and 15 years which correlates with the usual trend of having older children in younger classes than expected within the district because of the late enrolment of children in schools.

The prevalence of URE in this study is 1.8% which is consistent with the population-based Refractive Error Study in Children (RESC) conducted in South Africa (1.8%) (Naidoo et al., 2003). Nonetheless, it is lower than the prevalence from previous studies in Ghana by Ovenseri and Assien (13.3%) (Ovenseri-Ogbomo & Assien, 2010), Kuma et al. (3.3%) (Kumah et al., 2013) and in other parts of Africa by Opubiri and Egbe (2.2%) (Opubiri et al., 2013), Balarabe et al. (4.8%) (Balarabe et al., 2015) and Nebiyat et al. (4.0%) (Tefera, 2015). Importantly, the variations in these studies could be attributed to the difference in study/geographical area (rural or urban), study samples, ethnicity, age group of participants in the study and the definitions and methods used for classifying refractive errors. For instance, in the study by Nakua et al. (2015), they observed that children in urban areas are at higher risk of REs as compared with their rural counterparts which correlates with the low prevalence observed in this study as there was little/no differentiation within the sample area (that is, all children were classified as living in a rural setting). With regard to age, this study examined students aged 12 to 15 years while other studies examined students across different age groups. In one by Ovenseri-Ogbomo and Omuemu (2010) on the prevalence of RE among school children in the Cape Coast Municipality, Ghana, children between the ages of 5 and 19 years were enrolled and reported a higher prevalence of 25.6% while another in Agona Swedru in Ghana included children aged 11 to 18 years and reported a higher prevalence of 13.3% as well (Ovenseri-Ogbomo & Assien, 2010). Notably, these two studies used cycloplegic refraction in determining RE which is different from our study and could possibly be the reason for the low prevalence observed. While cycloplegic refraction would have provided information on latent hyperopia, especially in children with high amplitude of accommodation, non-cycloplegic refraction was used in this study as it was in other studies (Adegbehingbe et al., 2005; Mabaso et al., 2006; Ovenseri–Ogbomo & Assien, 2010). This method was used primarily to prevent blurry vision from any cycloplegic agent which would have interfered with the academic activities of the children as all examinations were conducted during school hours. It was also chosen in order to enable many parents who would otherwise have prevented their children from enrolling in the study on the basis of ethical reasons and reluctance to permit instillation of eyedrops in their children's eyes to do so. However, the prevalence of RE in our study is higher than that observed in another study conducted in public school settings in rural Tanzania which reported a prevalence of 1.0% (Wedner et al., 2002).

A multinomial logistic regression analysis showed that female students had higher risk of REs than males after adjusting for age (ARR: 2.7; 95% CI 1.2–6.3; z = 2.3; *P* = .02) which was similar to what was observed in previous studies conducted by Mabaso et al. on school children in South Africa (Mabaso et al., 2006) and Saad et al. on Egyptian school children (Saad & El-Bayoumy, 2007). Contrarily, a study conducted among Nepalese children found no association between gender and RE (Pokharel et al., 2000). The underlying cause for the variation in prevalence of RE among males and females should therefore be explored further as it is unclear.

The prevalence of myopia is highest in our study which is consistent with those reported by Kuma et al. in their RE study in private school children in Ghana (Kumah et al., 2013), Naidoo et al. in South Africa (Naidoo et al., 2003), Wedner et al. in Tanzania (Wedner et al., 2000) and Ngozika et al. in Nigeria (Ezinne & Mashige, 2018). This could partly be due to the fact that a non-cycloplegic refraction which reveals less hyperopia and more myopia was used. On the other hand, it could be said to be in conformity with the recent increase in the epidemic of myopia (Rudnicka et al., 2016). However, it is worth pointing out that other studies have reported astigmatism as the most common type of refractive error (Nakua et al., 2015; Ovenseri-Ogbomo & Omuemu, 2010). The most intriguing aspect of our study is the fact that none of the children with RE had any spectacle correction. This informs the decision to intensify public awareness and education on the need for spectacle wear as well as increase in access, availability, and affordability of spectacle correction for school children with URE. Further qualitative studies could also be conducted to explore the reasons children with URE had no spectacle correction.

While the study was limited by the use of non-cycloplegic refraction in ascertaining the refractive status of the children with URE, the findings cannot be overlooked as non-cycloplegic procedures have been used and validated in other studies. However, this study is borne on the strength that a larger sample size with a higher response rate was used which could lead to generalisation the results to the whole district.

5. Conclusion

Even though the prevalence of URE in this study is lower than that reported in different parts of the country, none of the children with RE had correction. There is, therefore, the need for further studies to be conducted to explore the underlying cause for the lack of correction for the children who have REs in the district. Future studies could also be carried out to investigate the varying prevalence of URE among children that exists between the northern and southern sectors of Ghana.

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None of the authors have any proprietary interests or conflicts of interest related to this submission.

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