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OPHTHALMOLOGY | RESEARCH ARTICLE

Prevalence and causes of visual impairment among schoolchildren in Mekelle, Ethiopia

Usha Dhanesha[1]*, Sarah Polack[2], Andrew Bastawrous[1] and Lena Morgan Banks[2]

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*Corresponding author: Usha Dhanesha, International Centre for Eye Health LSHTM, UK
E-mail: usha.dhanesha@googlemail.com

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Additional information is available at the end of the article

Abstract: Purpose: To estimate the prevalence and causes of visual impairment (VI), among primary school children in Mekelle, Ethiopia and the feasibility of teachers conducting vision screening in school using a smart phone application: Peek Acuity.

Methods: The study was conducted in four schools in Mekelle among children in their final 2 years of primary school (ages 11–15 years). Six teachers were trained in Peek Acuity, inter-observer variation was assessed and all teachers attained acceptable agreement (kappa>0.7) after one or two training sessions. Trained teachers then screened all eligible children for vision impairment in each eye using Peek Acuity. Children with visual acuity less than Log MAR 0.3 in either eye were examined by optometrists to determine the causes of VI.

Results: 1137 out of 1197 children participated (95.1%) with a mean age of 13 years. 141 children (12.4, 95% CI 10.5–14.3) had VI (presenting VA<0.3) in either one or both eyes. The prevalence of presenting VA<0.3 in the better eye was 6.7% (95% CI: 5.2–8.1) and the prevalence of unilateral VI (presenting VA<0.3 in one eye) was 5.7 % (95% CI: 4.4–7.2). Uncorrected Refractive Error was the leading cause of VI (89%). No children had previously worn spectacles.

Conclusion: High levels of unmet need for eye examination and spectacle provision were found. School-based screening using Peek Acuity was an effective means to

ABOUT THE AUTHOR

Ref: Prevalence and causes of visual impairment among schoolchildren in Mekelle, Ethiopia.
Dr Usha Dhanesha has an ongoing role in training and development of Eye Health Screening for School children in Tigray, Ethiopia. The study was undertaken as part of the Masters in Public Health in Gobal Eye Care at the London School of Hygiene and Tropical Medicine in the International Centre for Eye health.
Based on the study undertaken and the follow up interviews with the children, she is collaborating with Special Educational Needs Tigray, Tigray health and Education Boards and Quiha Eye Unit to develop sustainable Eye Health Services for school children in Mekelle. She holds a senior lectureship in Optometry within the department of postgraduate studies in Life and Medical Sciences at Hertfordshire University, and an honorary lecturer role at Warwick Medical School.

PUBLIC INTEREST STATEMENT

Prevalence and causes of VI among schoolchildren in Mekelle, Ethiopia.

Tigray is the northernmost region of Ethiopia with scant data held by the Regional Education and Health bodies about any requirements for a school eye health-screening programme locally.

Recent developments in Smart phone based eye examination has led to flexibility in screening eyes for poor vision and assessing the extent of VI and causes in the schoolchildren community.

Peek Acuity is an app which has been established as user friendly and compatible with conventional methods of assessing visual acuity.

The school based version of the app was used by teachers trained to identify school children with VI in the final two years of primary school.

High levels of unmet need for eye examination was found in children who benefitted from spectacle provision and treatment to restore vision.

identify and refer children who could benefit from spectacle correction and other treatment to restore vision.

Subjects: Medicine, Dentistry, Nursing & Allied Health; Medicine; Ophthalmology

Keywords: Ethiopia; visual; impairment; prevalence; causes; Peek Acuity; smartphone; children

1. Introduction

Globally there are an estimated 19 million children with Visual Impairment (VI), of which 12 million are due to Uncorrected Refractive Error (URE) (World Health Organisation, 2014a, 2014b). Evidence suggests that VI among children can be associated with reduced quality of life and lower educational opportunities (Sherwin, Lewallen, & Courtright, 2012). This may carry implications throughout the life-course, including in reduced occupation opportunities and increased risk of poverty (Banks, Kuper, & Polack, 2017; Kuper & Monteath-van, 2014; Powell, Wedner, & Hatt, 2008).

The prevalence of VI amongst children varies between different regions and between rural and urban areas within a country (Gilbert & Ellwein, 2008). VI is a public health issue as, particularly in low income settings, children may not have access to spectacles for URE or to other treatment to restore sight (Dandona, Dandona, & Srinavas et al., 2002; Murthy et al., 2002; Naidoo, 2012; Schneider, Leeder, Gopinath, Wang, & Mitchell, 2010; Zhao et al., 2000). A study on the prevalence of VI in school children in Africa suggested that the prevalence was too low to warrant vision screening being incorporated in school health programmes (Sharma, Congden, Patel, & Gilbert, 2012).

Within Ethiopia estimates of VI prevalence amongst school-aged children vary between 4%-9% (Demissie & Demissie, 2014; Kassa & Alene, 2003; Mehari, 2014; Nebiyat, Alemayhou, & Tigist, 2015; Worku & Bayu, 2002; Yared, Belaynew, Destaye, Ayanaw, & Zelalem, 2012). The variation in these estimates may partly reflect the different methodologies used including in definition of VI, age range included and type of school (private/public). In all these studies, however, URE was found to be the leading cause of VI in children (Baltussen, Naus, & Limburg, 2009; Sewunet, Aredo, & Gedefew, 2014).

A recent study of 378 school children in the capital city Addis Ababa found a VI prevalence of 5.8%, which lead to a recommendation of establishing a school-based vision screening programme, however there are no guidelines for the establishment of vision screening in Ethiopia (Darge, Shibru, Mulugeta, & Dagnachew, 2017). Vision screening in schools has been advocated as a key intervention for identifying and addressing VI early, and consequently mitigating its negative impacts on schooling and other outcomes. School-based vision screening, combined with provision of spectacles, has also been shown to be cost-effective (Baltussen et al., 2009).

However, a major challenge to vision screenings is the shortage of eye health professionals and resources, particularly in sub-Saharan Africa (Courtright et al., 2016; Palmer et al., 2014). For example, in Ethiopia, there are less than 3 optometrists per million Prevention of Blindness, 2017). To overcome this shortage in specialised resources, innovative solutions using new technology have shown promise. For example, the smart phone vision-screening app Peek Acuity based on the tumbling E optotype, has enabled vision screening to be undertaken outside clinical settings and by non-professionals (Bastawrous, 2016; Bastawrous, Rono, & Livingstone, 2015). Visual acuity using Peek has been validated against vision charts assessing Log MAR acuity and found to be accurate and repeatable (Bastawrous et al., 2015). Peek Acuity can also be used by non-specialists: for example it has been used by teachers in the Trans Nzoia County of Kenya to conduct school screenings (Morjaria & Bastawrous, 2017; Smith et al., 2012). Consequently, Peek is emerging as an important tool for school screening programmes as it is portable, user-friendly and low cost (Morjaria & Bastawrous, 2017; Smith et al., 2012).

In the Tigray, a predominantly rural region in northern Ethiopia, there are no available data on VI in schoolchildren with which to inform decisions about school eye health programmes (Nebiyat et al., 2015; Sewunet et al., 2014). To address this gap, this study aimed to assess the feasibility of vision testing by school teachers using Peek and to conduct a cross sectional survey to estimate the prevalence and causes of VI amongst school children, in the final years of primary school.

2. Materials and methods

2.1. Study population

The study was based in four government primary schools in Mekelle, North Ethiopia. Mekelle comprises two Woredas and two schools were selected from each Woreda on the basis of discussions with Heads of schools about availability of teachers for training, space for screening and eye examination. Only children in the final 2 years of primary school (ages 11–15 years) were included on the basis of the evidence that VI is thought to be higher in the older school children (Baltussen et al., 2009). This corresponds to Grades 7 and 8 within primary school. Based on an estimated prevalence of VI of 5% (Bastawrous, 2016) ±1.25%, a precision of 25 and 95% confidence interval, the required sample size was calculated to be 1,046 participants. Four schools with at least 300 children in Grades 7 and 8 were selected to achieve the desired sample size.

2.2. Vision survey

2.2.1. Training teachers

Six teachers volunteered to conduct the eye screening for the survey. After the purpose of the study was explained, they were trained in the use of Peek Acuity. None of the teachers had previous experience of using a smart phone. The teachers underwent one day of training in using Peek and storing data. An inter-observer variation (IOV) assessment was conducted during which each teacher screened the vision of 30 students, and their results were compared to those of an optometrist with experience of Peek (UD). Kappa values at ≥0.6 were required to participate in the survey. Teachers who failed to achieve this value underwent repeat training and a second IOV assessment until they reached the acceptable kappa value.

2.2.2. Eye examination

For the vision survey, two trained teachers worked in each school and screened on average 80 children per day. Vision screening was conducted indoors with a light level of approximately 100 candelas/m^2 at 2 m as required for screening with Peek Acuity.

The Peek Acuity application was directly installed on android smartphones. The methodology of presentation is described in a previous publication and involves the random presentation of the "tumbling E" optotype in one of four possible orientations (Bastawrous et al., 2015). If the letter E is correctly identified at log MAR 1.0, the optotype is presented at log MAR 0.3. The screen illumination was programmed to be constant within the algorithm. Presenting vision in each eye was tested separately.

Children who did not pass the screening (i.e. VA<0.3) in at least one eye underwent an eye examination at the school by optometrists to determine the level of VA (using a static log MAR tumbling E chart at 3 m) in the failed eye(s), cause and management. Children were asked about any history of spectacle wear, previous eye examinations and any other conditions requiring treatment. All children underwent a cycloplegic refraction and slit lamp examination of the anterior and posterior segment to determine cause of vision loss. If there was more than one cause of vision loss, we recorded principal cause as the condition easiest to treat following WHO protocol. The definition of refractive error and the criterion for recommending spectacles was presenting vision <0.3 correctable to ≥0.3. The spectacle prescriptions required for each child were recorded

2.3. Ethical considerations

Ethical approval was obtained from London School of Hygiene & Tropical Medicine and Tigray Education Bureau/Special Educational Needs (SEN) Tigray. Informed written/thumb-printed consent was sought from the caregivers of study participants and verbal assent was sought from the child. Caregivers were encouraged to attend on the days of screening and ask any additional questions about the study and child's vision test.

All caregivers were informed of the outcomes of screening of their children. Children requiring spectacles, ophthalmic or medical treatment were referred to Quiha Eye Unit and Ayder Hospital with caregiver's consent. Spectacles and treatment with review, if required, were provided with no costs incurred to the families.

3. Results

3.1. Vision testing by teachers

Four teachers attained good agreement with the optometrist in vision screening (Kappa: 0.7–0.9) after the first training session. The two remaining teachers attained the acceptable kappa values after a second training session. During an informal debrief after the study, the teachers reported positively about their experiences of using the smart phone app.

3.2. Study participants

Out of the 1,197 registered schoolchildren invited to join the study, 1,137 agreed to participate (response rate: 95.1%). Caregivers of 60 children (4.9%) refused to give consent for screening in one school, with the reason given that they had been advised against it by a local traditional healer. The mean age of the sample screened was 13 years (CI: 11–15), and the proportion of girls (55.5%), mean age 12.9 (11–15) was marginally higher than boys (44.5%), mean age13.1 (11–15.0). None of the children had any prior experience of wearing spectacles or had received treatment for any conditions affecting their vision.

Table 1 shows a total of 141 children (12.4, 95% CI:10.5–14.3)) were identified as having VI (presenting VA<0.3) in either one or both eyes (i.e. counted as 'failed screening'). As shown in Table 2, the prevalence of VI was higher among girls: 14.3% (95% CI:11.6–17) VI in one or both eyes compared to 10.1 %(7.5–12.3) of boys ($p = 0.02$). The prevalence of presenting VA <0.3 in the better eye was 6.7% CI: (5.2–8.1)

3.3. Severity of vision according to World Health Organisation (WHO) classifications

Among the 76 children who failed the Peek Acuity screening in both eyes, 58% had moderate VI (VA <0.3 to≥1.0 in better eye), 22% had severe vision impairment (<1.0 ≥ 2.0) and 20% were blind (<2.0).

3.4. Causes of vision impairment unilaterally and bilaterally

Table 3 shows that the vast majority of VI in one or both eyes was due to URE (89%). Ten children (7%) with VI had an ophthalmic condition requiring treatment which included conjunctivitis ($n = 5$), trachoma ($n = 3$) and Vitamin A deficiency ($n = 2$). Five (4%) were diagnosed with longstanding unilateral conditions considered untreatable which included amblyopia, corneal opacity and trauma.

Within the group with bilateral vision impairment, the VI of 66 children (89%) was restored to≥3 with spectacles and 10 (11%) were amenable to treatment.

3.5. Spectacles issued

The majority of the spectacles required to correct refractive error were for myopia and/or astigmatism: 67% ($n = 44$) of the children requiring spectacles had simple myopia, 25% ($n = 17$) myopia with astigmatism prescriptions and 8% ($n = 5$) were hyperopic.

Table 1. Characteristics of study sample

Characteristic	N (%)
Age in years	
10–11	76 (6.7%)
12–13	807(22.3%)
14–15	254 (22.3%)
Total	Total:1137
Mean age (95% CI)	13 (CI: 11–15)
Sex	
Male	506 (44.5%)
Female	631 (55.5%)
Grade	
Grade 7	592(52)
Grade 8	545 (48)
Visual Impairment (VI)	
Total Bilateral VI (VA<0.3 in better eye)	76 (6.7)
WHO VI Categories:	
(Moderate VI:<0.3 ≥ 1.0)	44 (3.9)
(Severe VI: <1.0 ≥ 2.0)	17 (1.5)
(Blind:<2.0)	15 (1.3)
Total unilateral VI (VA<0.3 in one eye	65 (5.7)
Total VI <0.3 in at least one eye ('failed' screening)	141 (12.4)

Table 2. Prevalence of presenting visual impairment (VI) by sex

	Bilateral VI (VA<0.3 in better eye)		Unilateral VI (VA<0.3 in one eye)		VI at least one eye (total number failing screening)	
	N	% (95% CI)	N	% (95% CI)	N	% (95% CI)
Total	76	6.7(5.2–8.1)	65	5.7(4.4–7.2)	141	12.4 (10.5–14.3)
Boys	27	2.4(1.5–3.3)	24	2.1(1.3–2.9)	51	10.1% (7.5–12.3)
Girls	49	4.3(3.1–5.5)	41	3.6 (2.5–4.7)	90	14.3 (11.6–17.0)

*p-value for difference between males and females = 0.02

Within the group requiring spectacles, 16% (11) of the correction required was symmetrical between the two eyes and therefore ready-made spectacles were issued at the time of examination. The remainder were glazed in the nearby hospital optical workshop and issued at a later date.

The majority of children reported being willing to wear their spectacles (92%). Six children (8%) were initially averse to spectacle wear, which was reduced to three who refused to wear spectacles after discussions between the parents, child and teachers with the Special Education Needs (SEN) coordinator. There was no assessment of long-term spectacle compliance built into the study design.

4. Discussion

This research provides data on the prevalence and causes of VI in school-aged children in Tigray, Ethiopia, information that had previously been lacking and is needed to inform local decision-making.

Table 3. Percentage and all causes of bilateral and unilateral vision impairment (VA<0.3)

Cause	Bilateral VI (n = 76)	Unilateral VI (n = 65)	Total with VI in one/ both eyes (n = 141)
Uncorrected refractive error	66 (87%)	60 (92%)	126 (89%)
Conjunctivitis Trachoma, Vitamin A deficiency, Trachoma	10 (13%)	0 (0%)	10 (7%)
Amblyopia, Corneal Opacity, Trauma	0 (0%)	5 (8)%	5 (4%)

In this study, six teachers with no prior experience of smart phone technology were successfully trained to conduct visual screening in primary schools using the Peek Acuity app. The prevalence of binocular VI (VA <0.3 in the better eye) was 6.7% and in total 12.4% had VI in one or both eyes. The vast majority of VI was due to avoidable causes: 89% was due to URE and a further 7% had conditions that were treatable. Only 4% had conditions that could not be treated and these were all unilateral.

The findings on prevalence and causes of VI mostly concur with previous studies undertaken among children in Ethiopia although the age ranges sampled spanned 5–15 years (Sharma et al., 2012; Sherwin et al., 2012). In the Northern regions, the prevalence of VI in this study in Mekelle, was comparable to two previous studies in the North- West region of Ethiopia: the Markos District showed a prevalence of URE of 10.2%in either or both eyes and Kola Diba (7.6%). Compared to a study undertaken more centrally, this study in Mekelle showed a higher prevalence of URE than was found in a smaller study in Addis Ababa, which reported 5.8% prevalence of VI in either or both eyes. None of the studies reported any child wearing spectacles (Darge et al., 2017; Nebiyat et al., 2015; Sewunet et al., 2014). In comparing the prevalence with studies in similar age groups of school children in other parts of Africa, URE in this study was considerably higher than in secondary school children in Tanzania (6.1%) although the age range in this study was much wider from 11 to 20+. In addition, 30.3% wore spectacles which may have contributed to a reduce prevalence of VI. Prevalence of VI was significantly high in junior high school pupils in Ghana (25.6%) with some spectacle coverage (Abu, Yeboah, Ocansey, Kyei, & Abokyi, 2015; Wedner et al., 2002). The relatively high VI prevalence found in this study in Mekelle and others in Ethiopia contradicts previously held views (Ovenseri-Ogbomo & Vo, 2010) that VI in school children in Africa is too low to warrant vision screening being incorporated in school health programmes (Sharma, Patel, & Gilbert, 2012). Furthermore, the majority of VI in this study, as with others, could be easily corrected by spectacles (Baltussen et al., 2009), and this could have substantial benefits to quality of life, educational experience and achievement. As with other studies conducted in Asia and Africa, screening by teachers has been shown to be effective in accurately detecting VI: for example, screening by schoolteachers in Tanzania had a sensitivity of 80% and specificity of 91% in detecting VI (Wedner, Ross, Balira, Kaji, & Foster, 2000). Still, some studies have questioned whether school-based screenings are cost-effective: for example, one study in India showed that screening children's vision in a healthcare setting was marginally more economical, compared with screening in schools (Frick, Riva-Clement, & Shankar, 2009). However, this evaluation did not include the indirect and opportunity costs to households—including transportation and time spent away from work, education—which, if taken into consideration, rendered school-based screening more cost effective (Frick et al., 2009). Furthermore, this study was conducted in India, where coverage of eye health professionals is higher than in Ethiopia and other areas of Africa. (International Agency for the Prevention of Blindness, 2017) Given the shortage of eye health professionals, first line screening by teachers can reduce the demand on these services that are in short supply. The use of Peek brings further utility, as it is user-friendly and allows for quick, low-cost screenings.

Finally, although URE is easily correctable with spectacles, previous studies have suggested low compliance with spectacle wear among children for various reasons, which include no perceived benefit (Megbelayin, 2013). The role of teachers in eye health screening and their input to compliance has been evaluated in India and shown that spectacle coverage is improved by screening in the school setting coupled with the provision of free spectacles. (Hannum & Zhang, 2012; Wedner, Masanja, Bowman, Todd, & Gilbert, 2008) In this study, free prescription spectacles were delivered to the school for distribution to the relevant pupils rather than parents negotiating the travel to the nearest eye health service 10–15 miles away in Qihar. Recent evidence, from China, suggests that vision screening of school-age children and adolescents for URE may improve spectacle wear and educational outcomes, if spectacle provision is free (Evans, Morjaria, & Powell, 2018; Ma, Zhou, & Yi et al., 2014).

Future studies are needed in Mekelle however, to assess the compliance when spectacles are delivered at school compared to issuing a prescription (Evans et al., 2018; Wedner et al., 2002).

4.1. Implications

Peek Acuity has been established as an accurate and repeatable mode of assessing vision (Bastawrous et al., 2015). This study demonstrates that school-based vision testing by teachers after 2 days training is feasible and allowed the utilisation of the Optometrists and Ophthalmologists available from Quiha and the Military Hospital to undertake the refraction and clinical examination to manage the causes of VI of the children who failed screening. However, inadequately sustainable service provision of eye professionals, spectacles and medicines are barriers to development of a school screening service which would need to be addressed alongside strategies to raise awareness in teachers, parents, children and the community about vision impairment. In our study, 60 children from one community did not attend screening, based on the perceived negative consequences of the programme, after the intervention of a local healer. Consequently, it would be important to start a dialogue with local stakeholders in the wider community to discuss the value of school eye health programmes (Smith et al., 2012).

4.2. Limitations

We only included children who are attending school therefore the prevalence values are not generalizable to the general population of children in that age range. The purposive sampling of four large government schools for the study—based on practical feasibility and availability of the head-teachers—may also limit the generalisability of the findings as it is possible that the selected schools may differ from others in the city. Further, as the study was conducted in an urban area, the findings may not be generalizable to rural areas. Although initial uptake of spectacles was high, we did not collect data on longer-term spectacle use and this should be explored in future studies. As myopia progresses with age, future studies should be extended to secondary schools as the prevalence may be higher in older age groups attending secondary education.

4.3. Conclusion

This study contributes to evidence on the epidemiology of VI amongst primary school children in Ethiopia. School based screening conducted by teachers using modern technologies such as Peek may be an effective means to identify and refer children who could benefit from spectacles and other treatment in this setting.

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Author details
Usha Dhanesha[1]
E-mail: usha.dhanesha@googlemail.com
Sarah Polack[2]
E-mail: sarah.polack@lshtm.ac.uk
Andrew Bastawrous[1]
E-mail: andrew.bastawrous@lshtm.ac.uk
Lena Morgan Banks[2]
E-mail: morgon.banks@lshtm.ac.uk
[1] International Centre for Eye Health LSHTM, London, UK.
[2] International Centre for Evidence in Disability, LSHTM, London, UK.

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