Strabismus

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/istr20

Prevalence and pattern of amblyopia in a rural hospital in Ghana

Akosua Kesewah Asare OD , Kwadwo Owusu Akuffo OD, PhD , David Ben Kumah OD, MPH , Eldad Agyei-Manu OD , Christine Karikari Darko OD & Emmanuel Kofi Addo OD

To cite this article: Akosua Kesewah Asare OD , Kwadwo Owusu Akuffo OD, PhD , David Ben Kumah OD, MPH , Eldad Agyei-Manu OD , Christine Karikari Darko OD & Emmanuel Kofi Addo OD (2020): Prevalence and pattern of amblyopia in a rural hospital in Ghana, Strabismus, DOI: 10.1080/09273972.2020.1779319

To link to this article: https://doi.org/10.1080/09273972.2020.1779319

Published online: 05 Jul 2020.

STRABISMUS
https://doi.org/10.1080/09273972.2020.1779319

Taylor & Francis
Taylor & Francis Group

Prevalence and pattern of amblyopia in a rural hospital in Ghana

Akosua Kesewah Asare, OD, Kwadwo Owusu Akuffo, OD, PhD, David Ben Kumah, OD, MPH, Eldad Agyei-Manu, OD, Christine Karikari Darko, OD, and Emmanuel Kofi Addo, OD

Department of Optometry and Visual Science, College of Science, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

ABSTRACT

Amblyopia is a developmental ocular disease of childhood-onset which may lead to persistent sequelae into adulthood. Early detection and management of amblyopia usually result in an improved visual outcome. The purpose of this study was to determine the prevalence and pattern of amblyopia in a rural hospital in Ghana. Clinical records of patients seen (from January 2014 to December 2018) at Westphalian Medical Center, Oyoko, Ashanti Region, Ghana, were reviewed retrospectively. Unilateral amblyopia was defined as a two-line interocular difference or more in visual acuity. Bilateral amblyopia was defined as best-corrected visual acuity (BCVA) of Snellen 6/12 or worse in both eyes, with evidence of bilateral ametropia or obstruction of the visual pathway. Following a review of 12,602 patient records, 258 cases of amblyopia were identified. The mean (±SD) presenting age of amblyopic patients was 24.3 ± 16.1 years, with a male-to-female ratio of 1:1.1. The period prevalence of amblyopia was 2.04%. The period prevalence of unilateral and bilateral amblyopia was 1.38% and 0.66%, respectively. The most prevalent form of amblyopia was refractive with a cumulative prevalence of 1.42%. Strabismic and stimulus deprivation amblyopia accounted for 0.36% and 0.21% of all amblyopic cases, respectively. A major cause of amblyopia in this population was refractive error, hence the use of spectacle correction for its initial management. Repeated assessment after an appropriate period of refractive adaptation would elucidate the proportion of amblyopias needing additional treatment modalities. Vision screening for early detection of amblyopia in childhood with accessible and effective management of amblyopia (including refractive correction and occlusion treatment) is necessary to reduce the impact of amblyopia in Ghana.

KEYWORDS

Amblyopia; refractive error; strabismus; prevalence

Introduction

Amblyopia is a developmental disorder caused by abnormal visual experience in the course of early visual development.[1] Clinically, amblyopia is defined as a unilateral or rarely bilateral decrease in vision, neither correctable by optical aid (glasses or contact lenses) nor attributable to any obvious ocular pathology.[2] Amblyopia is the most common cause of monocular visual impairment in children[3] and the second leading cause of poor vision in young adults.[4] It has an onset in childhood with persistent sequelae into adulthood. The effect of amblyopia is not only limited to a significant reduction in visual acuity (VA) but may also affect contour interaction, cause poor accommodation, reduce contrast sensitivity, cause abnormal eye movement, fixation instability, spatial distortion, and positional uncertainty.[5] Amblyopia resulting from suppression may functionally affect reading proficiency and has an impact on fine motor skills such as writing and drawing.[6] According to Birch et al.,[7] amblyopia affects self-perception in children and is a major hindrance in their academic performance, participation in athletics and general interaction with their peers. Besides the obvious monocular and binocular deficits associated with amblyopia, patients have a doubled lifetime risk of total blindness, with limits on career opportunities and an increased risk for anxiety and depression.[8] Some literature suggests that the treatment of amblyopia is expected to take place within an age window (sensitive period), after which treatment may be less effective.[9,10] However, current randomized clinical trials among adult amblyopic patients have shown small but significant improvement (0.05–0.30 logMAR lines in distance VA, after 4–16 weeks of optical treatment) in distant VA and overall binocular vision function.[11]

CONTACT Kwadwo Owusu Akuffo, OD, PhD. akuffokwadwoowusu@knust.edu.gh; koakuffo@gmail.com Department of Optometry and Visual Science, College of Science, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Globally, it is estimated that about 3% of children aged six years and below have some form of amblyopia with a lifetime risk of vision loss of about 1.2%.[12] The reported prevalence of amblyopia varies by study characteristics such as race or ethnicity,[13] criteria of the definition used[14] and geographic location.[15] The highest prevalence of amblyopia has been recorded among Caucasians, in European countries[7,12,16-18] and Hispanics.[19] Several population-based studies have been conducted in amblyopia and strabismus among preschool and school-aged children including the Pediatric Eye Disease Study among multiple ethnicities,[20,21] the Gutenberg Eye Health Study,[16] and the school-based assessment of amblyopia among multi-ethnic children in China[22] and Australia.[23,24] While many studies have reported the prevalence of amblyopia, a gap still exists regarding data on the prevalence and pattern of amblyopia in the African population. Even though there are reported prevalence rates for amblyopia, these rates are from refractive error surveys.[25,26] In Ghana, children start schooling as early as 2 years and as late as 6 years of age.[27,28] It is imperative that childhood vision screening is instituted to encompass the 'captive population' of amblyopia in the country. As such, an accurate estimate of the prevalence of amblyopia in an African population would provide useful information and recommendation for childhood vision screening programs as well as develop objective approaches for the treatment of amblyopia. Our goal, therefore, was to determine the pattern and prevalence of amblyopia and assess the treatment modalities employed in the management of amblyopia in a rural hospital in Ghana. To the best of our knowledge, this is the first study on the pattern and prevalence of amblyopia in Ghana and will serve as primary data for prospective studies. The current study only considers the prevalence in a (presumed symptomatic) group of patients who attended for hospital assessment.

Materials and methods

In this retrospective study, clinical folders of patients who were examined at the Westphalian Medical Center from January 1, 2014, to December 31, 2018, were reviewed. The Westphalian Medical Center is in Oyoko; a rural farming community in the Sekyere-Kumawu District (land size: 1,500.6 km^2 with a population of over 65,000 inhabitants) and serves as a major ophthalmic referral center in the Ashanti Region of Ghana. At first visit, patients receive a comprehensive eye examination including refraction and dilated fundus examination before a diagnosis is made.

Eligibility criteria

The inclusion criteria were all cases of reduced Snellen VA of 6/9 or worse. For children below age 3 years, VA/function was objectively estimated using the Bruckner and ocular alignment tests. Lost, defaced, or incomplete clinical records were excluded from the review process. Cases of glaucoma, cataract in adults, uveitis, retinal pathology, macular and optic nerve disorder, and visual field impairment were all excluded from this study.

All patients with any organic problems or findings which could be responsible for the reduction of VA were excluded.

Definition and classification of amblyopia

Amblyopia was defined using a modification of the Multi-Ethnic Pediatric Eye Disease Study (MEPEDS)[29] criteria. We classified amblyopia in two main ways: classification by subtypes and classification based on laterality. The classification by subtypes was based on three main diagnostic groups: refractive amblyopia, strabismic amblyopia, and deprivation amblyopia. An additional category was also defined as 'other,' which included all other forms of amblyopia (outside the three main diagnostic groups) such as amblyopia with visual loss superimposed by nystagmus or coloboma. Refractive amblyopia was defined as BCVA of Snellen 6/12 or worse with anisometropia (≥+1.00 D anisohyperopia, ≥−3.00 D anisomyopia, and ≥1.50 D anisoastigmatism), or bilateral ametropia (≥6.00 D of myopia, ≥4.00 D hyperopia or ≥2.00 D astigmatism). Strabismic amblyopia was defined as manifest strabismus evident on cover testing. Patients with mixed amblyopia (strabismus with anisometropia) were also placed in the same category as strabismic amblyopia. For patients who had degraded vision owing to congenital cataract, ptosis, or corneal scarring, they were classified as having deprivation amblyopia. The classification by laterality were unilateral amblyopia and bilateral amblyopia. Unilateral

amblyopia was defined as a two-line interocular difference or more in VA. Bilateral amblyopia was defined as BCVA of Snellen 6/12 or worse in both eyes, with evidence of bilateral ametropia or obstruction of the visual pathway.

Ethical consideration

This study was conducted in adherence to the declaration of Helsinki and was approved by the Committee on Human Research, Publication and Ethics (CHRPE) of the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana (CHRPE/AP/043/19), and the Hospital Board of the Westphalian Medical Center, Oyoko, Kumasi, Ghana.

Statistical analysis

Statistical analysis was conducted using Microsoft Excel Version 16 and Statistical Product and Service Solution (IBM Corporation SPSS® Statistics for Windows, Version 23.0). Descriptive statistics were used to determine frequencies and percentages of demographic characteristics. The prevalence rate for amblyopia was calculated as a percentage of the total patients eligible.

Results

Out of 12,860 clinical records of patients examined from January 2014 to December 2018, only 12,602 were eligible for this study. The mean (±SD) presenting age of amblyopic patients was 24.3 ± 16.1 years with minimum and maximum ages of 1 and 75 years, respectively, and slightly more of the patients being females (52.3%). Two hundred and fifty-eight cases of amblyopia were identified. The highest frequency of amblyopia was recorded among the 10–19 years age group. Table 1 shows the demographic characteristics of the amblyopia cases identified following review of clinical records.

Table 1. Demographic characteristics of amblyopia cases presented to the Westphalian Medical Center (2014–2018).

Variable	n (%)
Age group	
0 to 9	41(15.9)
10 to 19	90(34.9)
20 to 29	47(18.2)
30 to 39	31(12.0)
40 to 49	19(7.4)
50 to 59	23(8.9)
60 to 69	6(2.3)
70 to 79	1(0.4)
Sex	
Male	123 (47.7)
Female	135 (52.3)
Overall	258 (100)

n (%) represents the frequency and percentages respectively of demographic data.

Prevalence of amblyopia

The period prevalence of amblyopia in the Westphalian Medical Center from January 2014 to December 2018 was 2.04%. The highest and lowest point prevalence of amblyopia was recorded in 2014 (2.57%) and 2018 (1.96%), respectively (see Figure 1). The proportion of females with amblyopia to males was almost similar. In terms of age, amblyopia was only slightly more prevalent in children (50.8%) presenting to the hospital eye department than in adults (34.9% of the patients in the age range of 10 and 19 years).

Refractive amblyopia was found to be the most prevalent form of amblyopia (69.6%) among amblyopic patients within the 5-year period; being followed by strabismic amblyopia (17.8%) (see Figure 2). Anisometropic amblyopia accounted for 51.6% of the study population. The period prevalence of unilateral amblyopia was 1.38% accounting for more than two-thirds of the total amblyopia cases. A patient was twice more likely to have unilateral amblyopia than bilateral amblyopia.

Among the 258 amblyopic patients, 54.3% were given spectacle correction, 1.9% underwent strabismus surgery, and 14% were referred to a tertiary hospital (for further management). Neither patching nor penalization was prescribed for any of the patients (see Figure 3).

Discussion

This study presents new hospital-based data on the prevalence and pattern of amblyopia in a purely African population. In brief, the period prevalence of amblyopia was 2.04%, with a greater proportion being children. The proportion of females with amblyopia to males was almost similar. Refractive error and strabismus

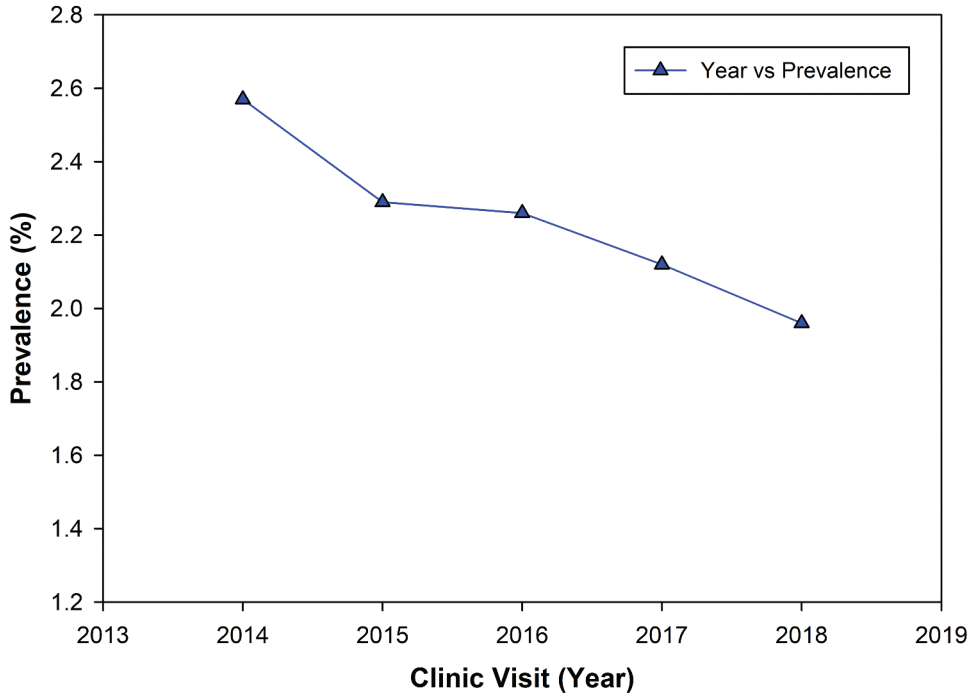

Figure 1. Line graph showing the pattern of amblyopia in a rural hospital in Ghana.

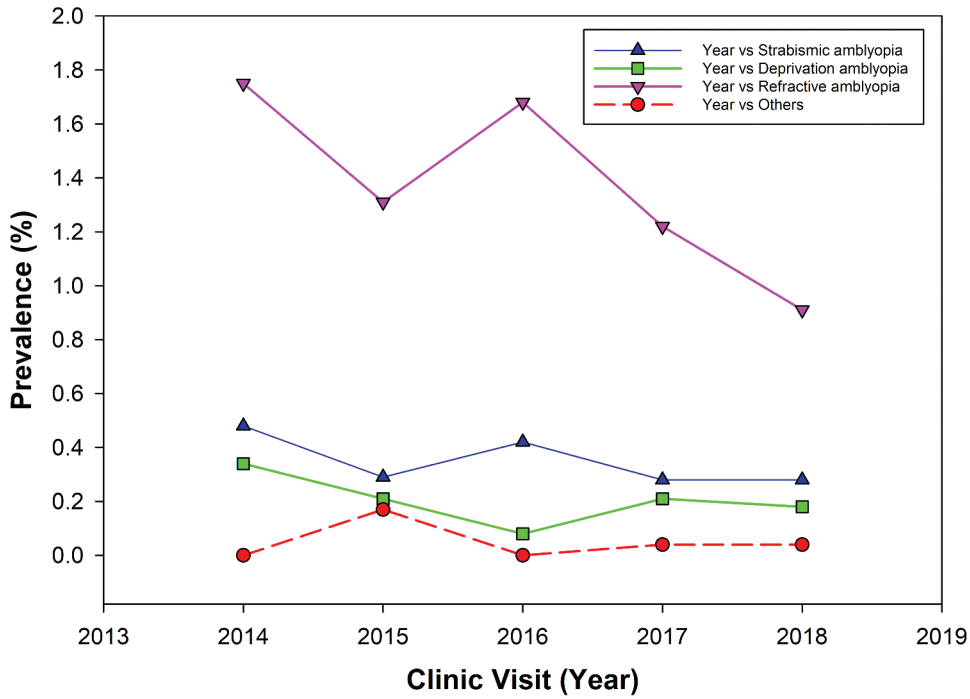

Figure 2. Line graph showing the pattern of amblyopia by clinical subtypes (in a rural hospital in Ghana).

were the major underlying causes of amblyopia in our study (with refractive amblyopia being the most predominant form of amblyopia). Spectacle correction was the most frequent treatment modality.

Globally, the prevalence of amblyopia ranges from 1% to 5%.[15] In this study, the prevalence of amblyopia in the hospital population was 2.04% which is comparable to previously reported rates among Vietnamese[30] and Iranian[31] school children.

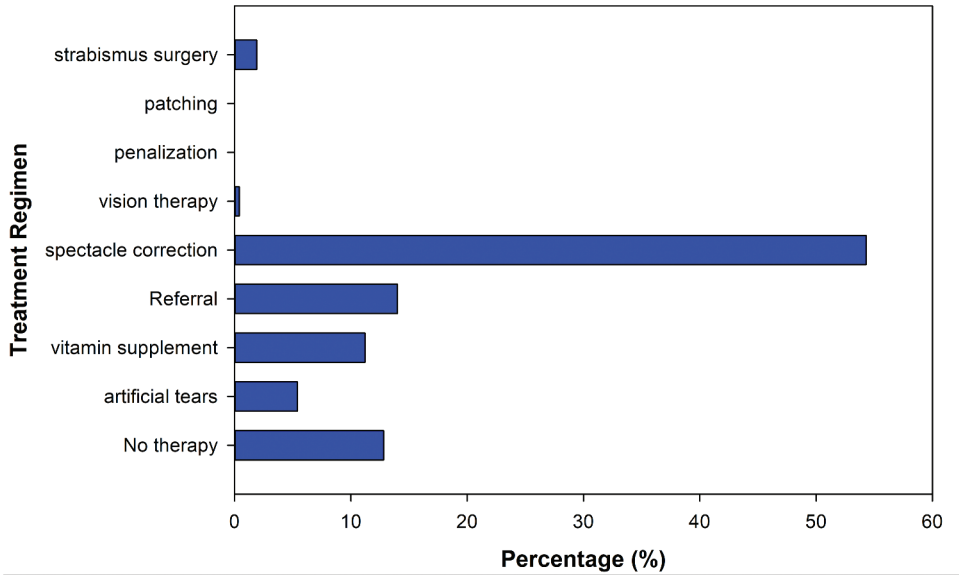

Figure 3. Bar chart showing various treatment regimen for amblyopia in a rural hospital in Ghana.

However, the prevalence rate was lower than that recorded in population-based studies among Caucasian populations: 5.6%[32]; 3.1%[33]; 2.6%[34]; but higher when compared to that among Chinese populations: 1.43%[35]; 1.2%[22]; 1.0%.[36] Lifestyle,[37] genetic susceptibilities,[38] and environmental factors may be contributing factors to the differences in rates among the different populations.

The prevalence of amblyopia in Africa (particularly Ghana) is generally generated from surveys on refractive error. For instance, Kumah et al.[39] reported a prevalence of 0.45% in a sample of 2,454 Ghanaian children aged 12 to 15 years. In a similar study by Naidoo et al.[26] among 5,599 South African children between 5 and 15 years, the prevalence of amblyopia was found to be 0.26%. The observed disparity in reported prevalence rate could be attributed to differences in the characteristics of study populations (age group, race, ethnicity),[40] sampling method, eligibility criteria, cut off point for VA,[41] and different amblyopia definitions.[15,42] For instance, both Kumah et al. and Naidoo et al., in their refractive error surveys among school children, set the criteria for amblyopia diagnosis as BCVA cut-off of Snellen VA of 6/12 with tropia, anisometropia, or hyperopia.

We also observed that the trend of amblyopia generally decreased over the 5 years. After the first year, the prevalence of amblyopia diagnosed in the hospital population declined from 2.57% to 2.29% and further decreased to 1.96% in the fifth year, indicating that a smaller number of cases of amblyopia were being recorded. In recent times, primary eye care has taken a different turn, where non-governmental organizations (NGOs) and local optometrists visit rural areas and organize community outreach programs[43] to offer free eye care services and appropriately refer cases that require further management. The Global Action Plan[44] (GAP) for Prevention of blindness was adopted with the objective of ensuring universal access to comprehensive eye care services without risk of impoverishment. The result of the GAP was the development and implementation of integrated national eye health policies including increasing eye health screening programs at the community level. There has been a sharp rise in the number of eye screening programs in the Ashanti region since 2015 as primary health-care workers including local optometrists visit rural areas and organize community outreach programs[43] to offer free eye care services and appropriately refer cases that require further management.

The study found that amblyopia was only slightly more prevalent in children (50.8%) presenting to the hospital eye department than in adults. This is consistent with a clinic-based retrospective study by Thompson et al.[45] However, Aldebasi[46] and Faghihi et al.[41] found the prevalence of amblyopia to be significantly higher in older age groups. Amblyopia may

have been underestimated in adults and this is likely due to ocular comorbidities[47] (such as cataract, glaucoma, age-related macular degeneration) associated with amblyopia in adults. We also observed that sex was not significantly associated with amblyopia, and this was similar to results from the MEPEDS,[29] MCRES,[48] ACES,[36] and STARS.[49]

Refractive error and strabismus were the major underlying causes of amblyopia in our study population, accounting for more than 70% of cases. Our finding was consistent with studies in three African populations[26,39,50] where amblyopia was found to be significantly associated with anisometropia (particularly anisohyperopia). Recent evidence indicates that full or partial optical correction within the critical and sensitive period improves VA appreciably, thus reducing the need for penalization and occlusion therapy.[51]

We observed that unilateral amblyopia was about two times more prevalent as compared to bilateral amblyopia, and this was consistent in most studies.[20,35,52] A possible explanation is the preservation of binocularity in bilateral ametropia (particularly isometropia) causing neural impulses to be transmitted to the visual cortex of both eyes.[53] Among studies involving Chinese populations, strabismic amblyopia is the leading form of amblyopia and this may be due to the lower prevalence of hyperopia[54] in the Chinese population. Interestingly, exotropia is markedly prevalent among participants in school-based amblyopia studies in Chinese ethnic groups, suggesting a myopic predisposition.[35,40,55]

From our findings, spectacle correction was the major treatment regimen, and thus provide evidence that refractive error is the major underlying cause of amblyopia in our study. This was consistent with findings by Caca et al.[34] and Robaei et al.[24] Neither penalization nor occlusion therapy was prescribed for the management of amblyopia in the study population. This is possibly due to the likely poor success of treatment arising from expected poor compliance.[56] There is also the case of the development of reverse amblyopia.[57] Another reason is that clinicians tend to prescribe full or partial optical correction instead of occlusion or penalization, as there is growing evidence to show that a period of wearing optical correction improves VA without any other treatment.[51] The reason for this trend could be the lack of information and understanding to convince parents (to appreciate the magnitude of the problem, and their role in the management[58]) on the need for such treatment. The management of amblyopia takes time and effort, and it is essential for the clinician to forge a relationship of trust between both patient and guardians; this enhances treatment compliance.[59] Another explanation for this trend is the possibility that clinicians feel the age at which diagnosis is made is not an optimum age for patching or penalization.[60] There is still ongoing debate on the age at which occlusion therapy is no longer beneficial as management for amblyopia.[61–64] Finally, the lack of facilities to monitor and initiate such treatments in the clinical setting may account for the observed trend. Due to the infrequent attendance of young children in general clinical practice, it is unlikely to find appropriate resources for carrying out such a treatment regimen.

The hallmark of a successful amblyopia treatment is early detection. The aim of the childhood vision screening program is to detect poor vision or certain risk factors (cataract, strabismus, high ametropia) for poor vision at a time when therapy can be initiated to achieve good visual outcomes. A Danish study that compared the prevalence of amblyopia before and after the introduction of a National Preschool Vision Screening program revealed that the prevalence of amblyopia decreased fourfold in one study[18] and by fivefold in another study.[65] This highlights the need for instituting childhood vision screening programs for early detection and management of amblyopia so as to reduce its prevalence.

The strength of this study is that it provides new data on the prevalence of amblyopia in a hospital population that reflects the characteristics of the condition in a typical rural setting in Ghana. Given the nature of the study area (i.e., rural) and no structured childhood vision screening program, most of the participants may rarely have had any form of vision screening; and thus, our prevalence estimates are likely to reflect the natural frequency of the disease. Furthermore, our study was not limited to school children and did not focus on only refractive errors as reported in previous African-based studies. Our study findings may guide clinicians to better understand the pattern of amblyopia

and potentially inform planning of childhood screening programs in Ghana and Africa at large. Data from this study will serve as baseline data for a population-based and prospective study on the prevalence and pattern of amblyopia in Ghana.

The limitation of this study was that the VA/function of three children younger than 3 years of age were included based on different (not VA) criteria. Due to the absence of VA screening tools for infants/toddlers (such as optokinetic nystagmus, visual evoked potentials) in Ghana, VA/function was objectively estimated using the Bruckner and ocular alignment tests.

In conclusion, amblyopia affected 1 in 50 people that visited the Westphalian Medical Center. A major cause of amblyopia in this population was refractive error, hence the use of spectacle correction for its initial management. Repeated assessment after an appropriate period of refractive adaptation would elucidate the proportion of amblyopias needing additional treatment modalities. Proper management of refractive errors may reduce the prevalence and impact of amblyopia in the Ghanaian population. Early detection of amblyopia through vision screening, with local provision of occlusion treatment and education on the benefits of treatment may be required to improve visual outcomes and reduce residual or untreated amblyopia in older children and adults.

Disclosure statement

The authors report no conflict of interest.

Funding

The research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ORCID

Akosua Kesewah Asare OD http://orcid.org/0000-0001-9457-6884
Kwadwo Owusu Akuffo OD, PhD http://orcid.org/0000-0001-6683-249X
David Ben Kumah OD, MPH http://orcid.org/0000-0002-4634-3637
Eldad Agyei-Manu OD http://orcid.org/0000-0002-2712-0198
Christine Karikari Darko OD http://orcid.org/0000-0003-2199-8415
Emmanuel Kofi Addo OD http://orcid.org/0000-0002-3836-2950

Availability of data and materials

The datasets generated during and/or analyzed during the current study are included in this published article.

Authors' contribution

AKA and KOA made substantial contribution to the conception and design of this work. AKA performed data collection. AKA, KOA, EAM, CKD, EKA, and DBK analyzed and interpreted the data. AKA and KOA wrote the initial draft manuscript. AKA, KOA, EAM, CKD, EKA, and DBK were major contributors in critically revising the manuscript. KOA supervised the study. All authors read and approved the final manuscript.

References

1. Hamm LM, Black J, Dai S, Thompson B. Global processing in amblyopia: a review. *Front Psychol*. 2014;5(583):1–21. doi:10.3389/fpsyg.2014.00583.
2. Ohlsson J. Defining amblyopia: the need for a joint classification. *Strabismus*. 2005;13(1):15–20. doi:10.1080/09273970590890949.
3. de Zarate BR, Tejedor J. Current concepts in the management of amblyopia. *Clin Ophthalmol*. 2007;1:403–414.
4. Robaei D, Wang JJ, Tan M, Rose KA, Kifley A, Mitchell P. Patterns of eyecare utilization by young Australian children: findings from a population-based study. *Ophthalmic Epidemiol*. 2006;13(3):153–158. doi:10.1080/09286580600630187.
5. Grant S, Moseley MJ. Amblyopia and real-world visuomotor tasks. *Strabismus*. 2011;19(3):119–128. doi:10.3109/09273972.2011.600423.
6. McKee SP, Levi DM, Movshon JA. The pattern of visual deficits in amblyopia. *J Vis*. 2003;3(5):380–405. doi:10.1167/3.5.5.
7. Birch EE, Castaneda YS, Cheng-Patel CS, et al. Self-perception of school-aged children with amblyopia and its association with reading speed and motor skills. *JAMA Ophthalmol*. 2019;137(2):167–174. doi:10.1001/jamaophthalmol.2018.5527.
8. Packwood EA, Cruz OA, Rychwalski PJ, Keech RV. The psychosocial effects of amblyopia study. *J Aapos*. 1999;3(1):15–17. doi:10.1016/S1091-8531(99)70089-3.
9. Fronius M, Cirina L, Ackermann H, Kohnen T, Diehl CM. Efficiency of electronically monitored amblyopia treatment between 5 and 16 years of age: new insight into declining susceptibility of the visual system. *Vision Res*. 2014;103:11–19. doi:10.1016/j.visres.2014.07.018.

10. Holmes JM, Lazar EL, Melia BM, et al. Effect of age on response to amblyopia treatment in children. *Arch Ophthalmol*. 2011;129(11):1451–1457. doi:10.1001/archophthalmol.2011.179.
11. Gao TY, Anstice N, Babu RJ, et al. Optical treatment of amblyopia in older children and adults is essential prior to enrolment in a clinical trial. *Ophthalmic Physiol Opt*. 2018;38(2):129–143. doi:10.1111/opo.12437.
12. Webber AL, Wood J. Amblyopia: prevalence, natural history, functional effects and treatment. *Clin Exp Optometry*. 2005;88(6):365–375. doi:10.1111/j.1444-0938.2005.tb05102.x.
13. Zhu H, Pan C, Sun Q, et al. Prevalence of amblyopia and strabismus in Hani school children in rural southwest China: A cross-sectional study. *BMJ Open*. 2019;9(2):bmjopen–2018. doi:10.1136/bmjopen-2018-025441.
14. Mocanu V, Horhat R. Prevalence and risk factors of amblyopia among refractive errors in an Eastern European population. *Medicina (Kaunas)*. 2018;54(1):6.
15. Hashemi H, Yekta A, Bostamzad P, et al. Global and regional estimates of prevalence of amblyopia: A systematic review and meta-analysis. *Strabismus*. 2018;26(4):168–183.
16. Elflein HM, Fresenius S, Lamparter J, et al. The prevalence of amblyopia in Germany: data from the prospective, population-based Gutenberg health study. *Deutsches Ärzteblatt Int*. 2015;112(19):338. doi:10.3238/arztebl.2015.0159.
17. Polling J-R, Loudon SE, Klaver CC. Prevalence of amblyopia and refractive errors in an unscreened population of children. *Optometry Vision Sci*. 2012;89(11):e44–e49. doi:10.1097/OPX.0b013e31826ae047.
18. Høeg TB, Moldow B, Ellervik C, et al. Danish rural eye study: the association of preschool vision screening with the prevalence of amblyopia. *Acta Ophthalmol*. 2015;93(4):322–329. doi:10.1111/aos.12639.
19. Borchert M, Tarczy-Hornoch K, Cotter SA, Liu N, Azen SP, Varma R. Anisometropia in Hispanic and African American infants and young children the multi-ethnic pediatric eye disease study. *Ophthalmology*. 2010;117(1):148–153.e141. doi:10.1016/j.ophtha.2009.06.008.
20. Friedman DS, Repka MX, Katz J, et al. Prevalence of amblyopia and strabismus in white and African American children aged 6 through 71 months: the baltimore pediatric eye disease study. *Ophthalmology*. 2009;116(11):2128–2134. e2122. doi:10.1016/j.ophtha.2009.04.034.
21. Fozailoff A, Tarczy-Hornoch K, Cotter S, et al. Prevalence of astigmatism in 6- to 72-month-old African American and Hispanic children: the multi-ethnic pediatric eye disease study. *Ophthalmology*. 2011;118(2):284–293. doi:10.1016/j.ophtha.2010.06.038.
22. Chen X, Fu Z, Yu J, et al. Prevalence of amblyopia and strabismus in Eastern China: results from screening of preschool children aged 36–72 months. *British J Ophthalmol*. 2016;100(4):515–519. doi:10.1136/bjophthalmol-2015-306999.
23. Pai A, Rose K, Leone J, et al. Amblyopia prevalence and risk factors in Australian preschool children. *Ophthalmology*. 2012;119(1):138–144. doi:10.1016/j.ophtha.2011.06.024.
24. Robaei D, Rose K, Ojaimi E, Kifley A, Huynh S, Mitchell P. Visual acuity and the causes of visual loss in a population-based sample of 6-year-old Australian children. *Am J Ophthalmol*. 2005;112:1275–1282.
25. Kumah BD, Ebri A, Abdul-Kabir M, et al. Refractive error and visual impairment in private school children in Ghana. *Optom Vis Sci*. 2013;90(12):1456–1461.
26. Naidoo KS, Raghunandan A, Mashige KP, et al. Refractive error and visual impairment in African children in South Africa. *Invest Ophthalmol Vis Sci*. 2003;44(9):3764–3770. doi:10.1167/iovs.03-0283.
27. Fentiman A, Hall A, Bundy D. School enrolment patterns in rural Ghana: a comparative study of the impact of location, gender, age and health on children's access to basic schooling. *Comparative Educ*. 1999;35(3):331–349. doi:10.1080/03050069927865.
28. UNESCO International Bureau of Education. *Ghana: Early Childhood Care and Education (ECCE) Programmes*. UNESCO Digital Library: United Nations Education, Scientific and Cultural Organization, Switzerland; 2007.
29. The Multi-Ethnic Pediatric Eye Disease Study Group. Prevalence of amblyopia and strabismus in African American and hispanic children ages 6 to 72 months. *Am Acad Ophthalmol*. 2008;115(8):1229–1236.
30. Paudel P, Ramson R, Naduvilath T, Wilson D, Phuong T, Giap N. Prevalence of vision impairment and refractive error in school children in Ba Ria – vung Tau province, Vietnam. *Clin Exp Ophthalmol*. 2014;42:217–226. doi:10.1111/ceo.12273.
31. Faghihi M, Ostadimoghaddam H, Yekta AA. Amblyopia and strabismus in Iranian schoolchildren, Mashhad. *Strabismus*. 2011;19(4):147–152. doi:10.3109/09273972.2011.622341.
32. Elflein HM, Fresenius S, Lamparter J, et al. The prevalence of amblyopia in Germany: data from the prospective, population-based Gutenberg Health Study. *Dtsch Arztebl Int*. 2015;112(19):338–344. doi:10.3238/arztebl.2015.0338.
33. Polling J, Loudon S, Klaver CW. Prevalence of amblyopia and refractive errors in an unscreened population of children. *Optometry Vision Sci*. 2012;89:44–49.
34. Caca I, Cingu AK, Sahin A, et al. Amblyopia and refractive errors among school-aged children with low socioeconomic status in Southeastern Turkey. *J Pediatric Ophthalmol Strabismus*. 2012;50(1):37–43. doi:10.3928/01913913-20120804-02.
35. Pan C, Chen X, Zhu H, et al. School-based assessment of amblyopia and strabismus among multiethnic children in rural China. *Sci Rep*. 2017;13410(7):1–7.
36. Fu J, Li MS, Li SY, et al. Prevalence, causes and associations of amblyopia in year 1 students in Central China. *Graefes Archives Clinicial Exp Ophthalmol*. 2014;252:37–143.

37. Lempert P. Amblyopia prevalence and cigarette smoking by women. *Ophthalmic Physiol Opt*. 2005;25(6):592–595. doi:10.1111/j.1475-1313.2005.00329.x.
38. Williams C, Northstone K, Howard M, Harvey I, Harrad RA, Sparrow JM. Prevalence and risk factors for common vision problems in children: data from the ALSPAC study. *Br J Ophthalmol*. 2008;92(7):959–964. doi:10.1136/bjo.2007.134700.
39. Kumah DB, Ebri A, Abdul-Kabir M, et al. Refractive error and visual impairment in private school children in Ghana. *Optometry Vision Sci*. 2013;90(12):1456–1461. doi:10.1097/OPX.0000000000000099.
40. Zhu H, Pan C, Sun DH, et al. Prevalence of amblyopia and strabismus in Hani school children in rural southwest China: a cross-sectional study. *British Med J*. 2019;25441(9):1–5.
41. Faghihi M, Hashemi H, Nabovati P, et al. The prevalence of amblyopia and its determinants in a population-based study. *Strabismus*. 2017;25(4):176–183. doi:10.1080/09273972.2017.1391849.
42. Rafiei M, Rivakani F, Torabi L, Alaeddini F, Safiri S. Community-based amblyopia screening program for early detection in Iran: a repeated cross-sectional study from 1996 to 2013. *Public Health*. 2017;142:196–200. doi:10.1016/j.puhe.2015.06.011.
43. Morny EKA, Boadi-Kusi SB, Ocansey S, Kyei S, Yeboah K, Mmaduagwu MA. Assessing the progress towards achieving "VISION 2020: the right to sight" initiative in Ghana. *J Environ Public Health*. 2019;2019:1–10. doi:10.1155/2019/3813298.
44. World Health Organisation. Universal eye health: a global action plan 2014-2019. *WHO Lib Catal Pub Data2013*;2013:1–28.
45. Thompson JR, Woodruff G, Hiscox FA, Strong N, Minshull C. The incidence and prevalence of amblyopia detected in childhood. *Public Health*. 1991;105:455–462.
46. Aldebasi YF. Prevalence of amblyopia in primary school children in Qassim Province, Kingdom of Saudi Arabia. *Middle East Afr J Ophthalmol*. 2015;22(1):81–91. doi:10.4103/0974-9233.148355.
47. Pinazo-Duran MD, Zanon-Moreno V, Garcia-Medina JJ, Arevalo JF, Gallego-Pinazo R, Nucci C. Eclectic ocular comorbidities and systemic diseases with eye involvement: a review. *Biomed Res Int*. 2016;2016:6215745.
48. Xiao O, Morgan I, Ellwein L, He M. Prevalence of amblyopia in school-aged children and variations by age, gender, and ethnicity in a multi country refractive error study. *Ophthalmology*. 2015;122:1924–1931. doi:10.1016/j.ophtha.2015.05.034.
49. Dirani M, Chan YH, Gazzard G, et al. Prevalence of refractive error in Singaporean Chinese children: the strabismus, amblyopia, and refractive error in young Singaporean Children (STARS) study. *Invest Ophthalmol Vis Sci*. 2010;51(3):1348–1355. doi:10.1167/iovs.09-3587.
50. Noche CD, Kagmeni G, Bella AL, Epee E. Prevalence and etiology of amblyopia of children in Yaounde (Cameroon), aged 5-15 years. *Sante (Montrouge, France)*. 2011;21(3):159–164. doi:10.1684/san.2011.0254.
51. Williams C. Amblyopia. *BMJ Clin Evid*. 2009;2009:1–17.
52. Chen Y, Chen X, Chen J, Zheng J, Xu J, Yu X. Longitudinal impact on quality of life for school-aged children with amblyopia treatment: perspective from children. *Curr Eye Res*. 2016;41(2):208–214. doi:10.3109/02713683.2015.1011280.
53. von Noorden GK, Crawford ML. The sensitive period. *Trans Ophthalmol Soc UK*. 1979;99:442–446.
54. Ying G, Maguire MG, Cyert LA, et al. Prevalence of vision disorders by racial and ethnic group among children participating in head start. *Am J Ophthalmol*. 2014;121(13):630–636.
55. McKean-Cowdin R, Cotter S, Tarczy-Hornoch K, et al. Prevalence of amblyopia or strabismus in Asian and non-Hispanic white preschool children. *Am Acad Ophthalmol*. 2013;120(10):2117–2124. doi:10.1016/j.ophtha.2013.03.001.
56. Stewart CE, Stephens DA, Fielder AR, Moseley MJ. Objectively monitored patching regimens for treatment of amblyopia: randomised trial. *Bmj*. 2007;335(7622):707. doi:10.1136/bmj.39301.460150.55.
57. Hainline BC, Sprunger D, Plager D, Neely D, Guess MG. Reverse amblyopia with atropine treatment. *Binocul Vis Strabismus Q*. 2009;24:25–31.
58. Al-Yahya A, Al-Odan K, Allam K, Al-Onazi B, Mousa A, Al-Saleh AA. Compliance to patching in the treatment of amblyopia. *Saudi J Ophthalmol*. 2012;26(3):305–307. doi:10.1016/j.sjopt.2012.05.003.
59. Karlica D, Matijević S, Galetović D, Znaor L. Parents' influence on the treatment of amblyopia in children. *Acta Clin Croat*. 2009;48:427–430.
60. Piano ME, Simmers AJ. 'It's too late'. Is it really? Considerations for amblyopia treatment in older children. *Ther Adv Ophthalmol*. 2019;11:2515841419857379. doi:10.1177/2515841419857379.
61. Tailor V, Bossi M, Greenwood JA, Dahlmann-Noor A. Childhood amblyopia: current management and new trends. *Br Med Bull*. 2016;119(1):75–86. doi:10.1093/bmb/ldw030.
62. Mohan K, Saroha V, Sharma A. Successful occlusion therapy for amblyopia in 11- to 15-year-old children. *J Pediatr Ophthalmol Strabismus*. 2004;41(2):89–95. doi:10.3928/0191-3913-20040301-08.
63. Patwardhan NA. Is age relevant for the success of treatment of anisometropic amblyopia? *Indian J Ophthalmol*. 2007;55(6):469–470. doi:10.4103/0301-4738.36488.
64. Scheiman MM, Hertle RW, Beck RW, et al. Randomized trial of treatment of amblyopia in children aged 7 to 17 years. *Arch Ophthalmol*. 2005;123(4):437–447.
65. Eibschitz-Tsimhoni M, Friedman T, Naor J, Eibschitz N, Friedman Z. Early screening for amblyogenic risk factors lowers the prevalence and severity of amblyopia. *J Aapos*. 2000;4(4):194–199. doi:10.1067/mpa.2000.105274.