Profile of amblyopia at Sabatia Eye Hospital

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ABSTRACT

Background: Amblyopia is a visual development disorder whose onset is in childhood. It becomes resistant to treatment after the critical age of 7 – 8 years when the visual system is estimated to have matured. Early diagnosis is vital to the prevention of visual impairment caused by amblyopia.
Objective: This study aims to determine the proportion and profile of amblyopia among children who presented at the Sabatia Eye Hospital in 2014.
Methods: This was a quantitative, hospital-based, retrospective case series. All children aged below 16 years who fit the amblyopia case definitions and were seen at Sabatia Eye Hospital between 1st January and 31st December 2014 were included in the study. The 2014 outpatient records were used to recruit the study population.
Results: A total of 268 patients (451 eyes) were recruited in the study from the 4,269 files assessed, giving a proportion of 6.3%. Most patients [183 (68.28%)] had bilateral amblyopia. Refractive amblyopia (56.54%) was the most common type and it was predominantly due to ametropia. Two thirds of children with refractive amblyopia presented after the age of 8 years. The second most common type of amblyopia was combined (31.49%) followed by sensory deprivation (9.31%) and strabismic (2.66%) amblyopia. Moderate amblyopia (58.47%) was more common than deep amblyopia (41.53%) and was predominantly due to refractive errors.
Conclusion: Refractive amblyopia is the most common type of amblyopia and has a predominantly late diagnosis. Pre-school vision screening programmes are recommended for early diagnosis and timely treatment.

Key words: Amblyopia, Paediatric ophthalmology, Kenya, Sabatia Eye Hospital, Strabismus, Refractive error, Sensory deprivation

INTRODUCTION

Amblyopia is a reduction in the best spectacle corrected visual acuity that cannot be attributed to any structural abnormality of the eye or the posterior visual pathways[1]. There are 3 main types – strabismic, refractive and stimulus deprivation amblyopia.

Vision normally develops when the brain is stimulated by a clear retinal image from each eye. If the retinal image is not clear, the brain learns to ignore images from this eye and use the clear image from the other dominant eye leading to amblyopia.

The first few months of life are the most vulnerable to amblyopia, and this vulnerability to induction of amblyopia decreases with increasing age. There is a critical period, estimated to be up to 7 - 8 years, when amblyopia is reversible using various treatments options because the visual system is still developing. At the end of the critical period, the visual system has usually developed to full maturity, and the decrease in visual acuity is irreversible. Delay in or lack of treatment results in a lifetime of irreversible visual impairment in one or both eyes. Early diagnosis is therefore vital in the prevention of blindness and visual impairment caused by amblyopia. Response to treatment varies based on age of the patient[1-3] depth of amblyopia[1-3], type of amblyopia[1,4], choice of therapeutic approach[1,3] and compliance with treatment[1,4].

The United Kingdom[5] and United States of America[6] have published recommendations for vision screening in children in order to pick up strabismus, amblyopia and refractive errors. In Kenya, the Maternal and Child health booklet includes an eye assessment at birth, 6 months and 9 months aimed at picking up squint and a white reflex.

It is notable that studies in Kenya[7,8] have shown amblyopia to be a cause of visual impairment and blindness in children. However, there is lack of amblyopia-specific studies in Kenya. This study was therefore justified given the fact that amblyopia is a treatable cause of low vision and blindness (with long term impact on quality of life and occupation in adulthood), and that treatment is more successful if started within the critical period of visual development.

The objective of this study was to determine the proportion of amblyopia among the children who presented at Sabatia Eye Hospital in 2014, to determine the different types of amblyopia, to determine the depth of amblyopia, and to assess the catchment area of these children.

MATERIALS AND METHODS

Design: Quantitative, hospital-based, retrospective case series study at Sabatia Eye Hospital, a tertiary/referral eye hospital in the rural setting of Vihiga County, western Kenya.

Study population: All children aged below 16 years who fit the amblyopia case definitions and were seen at Sabatia Eye Hospital between 1st January 2014 and 31st December 2014 were included. Missing files, and files with incomplete records were excluded.

Case definitions

Unilateral amblyopia
Quantitative visual acuity measurement: ≥2-line interocular difference in Best Corrected Spectacle Visual Acuity (BCSVA) or BCSVA of Snellen ≤6/12 (20/40) (LogMAR 0.3), AND amblyogenic risk factor (Strabismus, Refractive error, Stimulus deprivation), AND no other structural abnormality of the eye or the posterior visual pathways.
Qualitative visual acuity measurement: Strong fixation preference for one eye and inability to hold fixation with the non-preferred eye, plus unilateral amblyogenic factor, AND no other structural abnormality of the eye or the posterior visual pathways.

Bilateral amblyopia: Bilateral subnormal Best Corrected Spectacle Visual Acuity (BCSVA) [worse than 20/50 (6/15) (LogMAR 0.4) in 30 to 47 month old children, or worse than 20/40 (6/12) (LogMAR 0.3) in ≥ 48 month old children], AND either of evidence (past or present) of bilateral visual axis obstruction or bilateral ametropia (≥ 4.00D spherical equivalent hyperopia; ≥ 6.00D spherical equivalent myopia; ≥ 2.50D astigmatism), AND no other structural abnormality of the eye or the posterior visual pathways.

Strabismic amblyopia: Amblyopia (as per case definitions above) and heterotropia at distance or near fixation or a history of strabismus surgery and absence of combined amblyopia.

Anisometropic amblyopia: Amblyopia (as per case definitions above) AND anisometropia (≥ 1.00 D anisohyperopia or ≥3.00 D anisomyopia or ≥1.50 D anisoastigmatism) AND absence of combined amblyopia.

Ametropic amblyopia: Amblyopia (as per case definitions above) AND bilateral high ametropia (≥ 4.00 D hyperopia or≥ 6.00 D myopia or ≥ 2.50 D astigmatism) AND absence of combined amblyopia.

Meridional amblyopia: Amblyopia (as per case definitions above) AND potential visually significant astigmatism in both eyes (Regular astigmatism >1.00 D of astigmatism in any meridian or irregular astigmatism in both eyes) AND absence of combined amblyopia.

Sensory deprivation amblyopia: Amblyopia (as per case definitions above) and past or present visual axis obstruction by cataract, corneal opacities, vitreous haemorrhage, congenital ptosis, hyphema, occlusion amblyopia or any other media opacity and absence of combined amblyopia.

Combined mechanism amblyopia: A combination of the various types of amblyopia: Combined strabismic and refractive amblyopia; Combined strabismic and sensory deprivation amblyopia; Combined sensory deprivation and refractive amblyopia; Combined strabismic, refractive and sensory deprivation amblyopia.

Data collection methods

Outpatient records book was used to identify all children <16 years who were seen between 1st January to 31st December 2014. The files were perused to identify children who met the case definitions and in whom onset of the amblyogenic factor was before the age of 8 years. The study data collection form was filled out for each case of amblyopia and the data analyzed. Information collected included age at first presentation, residence, cycloplegic refraction, best corrected spectacle visual acuity, strabismus type, prism diopters and type of sensory deprivation.

Ethics

Written approval for the study was obtained from Sabatia Eye Hospital and the Kenyatta National Hospital - University of Nairobi (KNH/UON) Ethics and Research Committee.

RESULTS

A total of 268 children (out of the 4,269 files perused) met the case definitions and were enrolled in the study. Therefore 6.3% of the children who visited the hospital in 2014 had amblyopia. There were 136 (50.75%) male and 132 (49.25%) female children. Bilateral amblyopia [183 (68.28%)] was more common than unilateral amblyopia [85 (31.72%)]. Due to the bilateral cases, the total number of eyes in the study was 451.

Table 1: Types and subtypes of amblyopia (n = 451)

	Amblyopia type	No.		(%)
1	**Refractive amblyopia**	255		56.54
	a) Combined ametropia and meridional		108	23.95
	b) Pure ametropia		55	12.20
	c) Pure meridional		40	8.87
	d) Combined anisometropia and meridional		25	5.54
	e) Combined anisometropia, ametropia and meridional		21	4.66
	f) Combined anisometropia and ametropia		4	0.89
	g) Pure anisometropia		2	0.44
2	**Combined amblyopia**	142		31.49
	a) Combined sensory deprivation and refractive		109	24.17
	b) Combined strabismic, refractive and sensory deprivation		16	3.55
	c) Combined strabismic and refractive		11	2.44
	d) Combined strabismic and sensory deprivation		6	1.33
3	**Pure sensory deprivation amblyopia**	42		9.31
4	**Pure strabismic amblyopia**	12		2.66
	Total	451		100.00

There were 4 main types of amblyopia with refractive amblyopia (56.54%) being the most common and pure strabismic amblyopia (2.66%) being the least common type. The other two types of amblyopia were combined amblyopia and pure sensory deprivation amblyopia. Refractive amblyopia was further classified into 7 subtypes while combined amblyopia was further classified into 4 subtypes. Combined ametropic and meridional amblyopia (42.35%) was the most common sub-type of refractive amblyopia followed by pure ametropia (21.57%). Combined sensory deprivation and refractive amblyopia was the dominant (76.76%) subtype of combined amblyopia.

The two largest contributors to bilateral amblyopia were refractive (62.30%) and combined (27.87%) amblyopia (Figure 1).

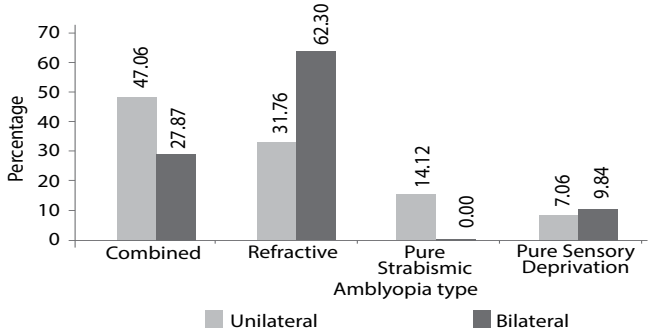


Figure 1: Bar chart showing the contribution of each amblyopia type to unilateral and bilateral amblyopia (n=451).

Half of the patients with all types of amblyopia first presented after the critical age of 8 years. The modal age at first presentation was 10 years (11.97%) (Table 2).

Table 2: Frequency distribution table showing age at first presentation for all amblyopia types (n=451)

Age (years)	Number of eyes	Relative frequency (%)	Cumulative %
<1	32	7.10	7.10
1	14	3.10	10.20
2	24	5.32	15.52
3	11	2.44	17.96
4	17	3.77	21.73
5	35	7.76	29.49
6	29	6.43	35.92
7	20	4.43	40.35
8	43	9.53	49.89
9	25	5.54	55.43
10	54	11.97	67.41
11	19	4.21	71.62
12	37	8.20	79.82
13	32	7.10	86.92
14	38	8.43	95.34
15	21	4.66	100.00
Total	451		

Only 32.16% of children with refractive amblyopia had their first presentation on or before the age of 8 years. In contrast, most of the children with pure sensory deprivation amblyopia (61.9%), pure strabismic (75%) and combined (76.06%) amblyopia had their first presentation to hospital on or before the critical age of 8 years (Figure 2).

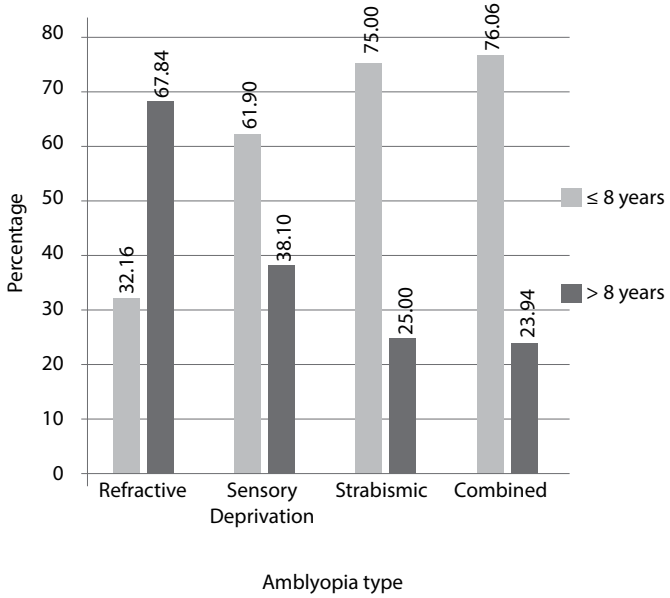


Figure 2: Age at first presentation for the four amblyopia types

The overall median age at first presentation was 9 years. It was highest for refractive amblyopia at 10 years and lowest for strabismic amblyopia at 3 years. It is notable that the modal age at first presentation for children with combined amblyopia was <1 year (Table 3).

Table 3: Measures of location for age at first presentation (n = 451)

	Amblyopia type	Age at first presentation		
		Mean	Median	Mode
1	Refractive Amblyopia	10.09	10	10
2	Sensory Deprivation Amblyopia	6.77	6.5	5
3	Combined Amblyopia	5.52	5	<1
4	Strabismic Amblyopia	4.40	3	4
	Total	8.19	9	10

Table 4: Measures of location for spherical equivalent based on amblyopia type and subtype

	Amblyopia type	Spherical equivalent		
		Mean	Median	Mode
1	Pure strabismic amblyopia	+0.60	+0.75	+1.00
2	Combined amblyopia	+0.19	-1.25	-1.38
3	Pure sensory deprivation amblyopia	-0.17	-0.38	-0.38
4	Refractive amblyopia	-8.05	-8.50	-9.00
	Total	-4.75	-5.00	-9.00

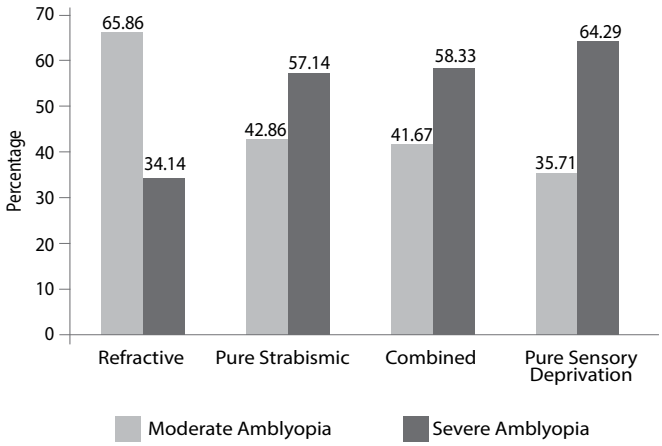
Eyes with refractive amblyopia were highly myopic

Causes of sensory deprivation: Sensory deprivation was an amblyogenic factor in 173 eyes (108 patients). Cataract was the most common (88.20%) cause of sensory deprivation. Other causes included corneal opacity, posterior capsule opacity, congenital pupillary membrane and congenital ptosis.

Type of tropia in the eye with strabismic amblyopia: Strabismus was an amblyogenic factor in 45 out of the 451 eyes enrolled in the study. Esotropia (67%) was found to be the most common form of strabismus, followed by exotropia (31%) and hypertropia (2%) (p-value 0.00).

Most (73%) of the eyes with strabismus were in the combined amblyopia category, as opposed to the pure strabismic amblyopia (27%) category.

Depth of amblyopia was predominantly moderate for refractive amblyopia (65.86%) [p-value 0.00] and predominantly severe for pure sensory deprivation amblyopia (64.29%) [p-value 0.04] and pure strabismic amblyopia (57.14%) [p-value 0.01] (Figure 3).



*354 of the 451 eyes had quantitative amblyopia assessment. The remaining 97 (21.51%) had a qualitative amblyopia assessment.

Figure 3: Clustered bar chart showing the percentage of moderate and severe amblyopia for the four amblyopia types (n=354*)

All the patients came from the Western and North-Western parts of Kenya. Most of the patients came from Kisumu county (19.78%) followed by Kakamega county (13.81%) and Vihiga county (12.69%) (Figure 4).

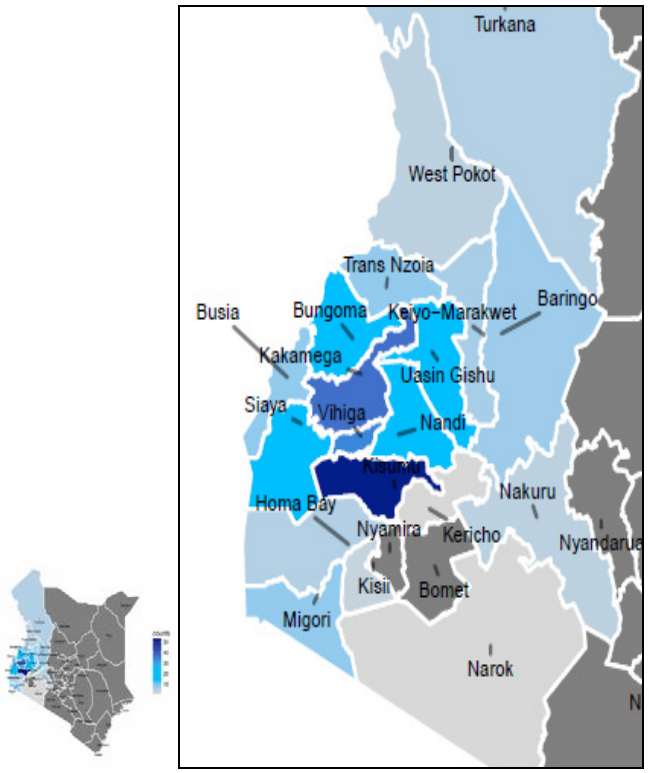


Figure 4: Catchment area for all children with amblyopia (n=268)

DISCUSSION

Proportion: This study found that 6.3% of the children aged <16 years who attended Sabatia Eye Hospital outpatient eye department in 2014 had amblyopia. This proportion was found to be 9.1% at Menelik II Hospital paediatric ophthalmology clinic in the capital city of Ethiopia[10] and 14.3% at Grarbet Eye Hospital outpatient eye department in rural Ethiopia[11].

The type of hospital setting where the patients present may have an influence on the proportions obtained in various studies, that is, whether they presented to a general or eye hospital; the general outpatient eye department[9,11,12] or to a specialized paediatric ophthalmologist[10,13] or orthoptic clinic[12,14,15].

This proportion of 6.3% gives us an indication of the burden of the disease in this rural hospital and is useful for planning purposes. The proportion may seem relatively low, but is actually significant considering that these are children who still have many years ahead of them. The Disability-adjusted Life Year (DALY) and Quality-adjusted Life Year (QALY) will be affected significantly in the children with unilateral amblyopia, while blind-person years will be increased for the children with untreated severe bilateral amblyopia.

Demographics: The number of male [136 (50.75%)] and female [132 (49.25%)] patients was almost equal. This finding is similar to that of Woldeyes *et al*[10] in Ethiopia where 49.7% were male while 50.3% were female. Bilateral amblyopia [183 (68.28%)] was more common compared to unilateral amblyopia [85 (31.72%)] [p-value of 0.00]. This is explained by the finding that 94 patients (35.07%) in this study had ametropia which by definition is bilateral. Additionally, 60 patients (22.3%) had bilateral sensory deprivation due to bilateral cataract. In contrast, Woldeyes *et al*[10] found 88% of cases were unilateral and the most common cause of amblyopia was strabismus.

Types and subtypes of amblyopia: Comparison of the types of amblyopia among different studies was challenging due to the variation in classifications and specific case definitions among the different studies. For example, in the "ametropic amblyopia" case definition, Chua *et al*[12] and Menon *et al*[14] used a cut-off of >1D spherical equivalent, while Woldeyes *et al*[10] used >1.5D spherical equivalent. This study's cut-offs (≥ 4.00D spherical equivalent hyperopia, ≥ 6.00D spherical equivalent myopia and ≥2.50D astigmatism) were based on the Multi-Ethnic Pediatric Eye Disease Study Group (MEPEDS)[17] and Baltimore Pediatric Eye Disease Study (BPEDS)[18] which are cognizant of the normal variations in refractive status of younger children and that high (not low) bilateral refractive errors are amblyogenic.

It has been widely reported in various books[1] and studies[10,12,15] that strabismus is the most common cause of amblyopia. However, refractive amblyopia was the most common type in this study. It is not uncommon for an amblyopia study to find high proportions of refractive amblyopia compared to strabismic amblyopia. Ganekal *et al*[16] had results that are quite similar to this study in that a large proportion of eyes had refractive error and few had strabismus – ametropia 50%; anisometropia 40.9%; strabismus 6.8%. Anisometropic amblyopia was the most common type in studies by Sharma *et al*[13] (33.33%) and Høeg *et al*[19] (45.5%). Chia *et al*[20] in Singapore found refractive (85%) to be the most common amblyopia type followed by strabismus (15%) with the most frequent refractive errors being anisometropia (42%) and isometropia / ametropia (29%).

The high proportion of refractive amblyopia in this study is suggestive of a high population prevalence of refractive errors which are diagnosed late. A screening programme would therefore be useful.

Age at first presentation: Late presentation was mostly attributable to refractive amblyopia as 67.84% presented after the age of 8 years unlike sensory deprivation (38.1%), strabismic (25%) and combined (23.94%) amblyopia. Possible explanations are that pure refractive amblyopia does not have an outwardly visible manifestation, tends to give a moderate rather than severe amblyopia which is easier to miss, and the child is unlikely to complain of poor vision. The interquartile range for refractive amblyopia (8 to 13 years) is the school going age. It's therefore likely that poor visual acuity was picked up when the child started going to school and noted to have difficulty seeing the blackboard. In contrast, the interquartile range for sensory deprivation (2 to 10.75 years), strabismic (0.96 to 5.5 years) and combined amblyopia (2 to 8 years) included the pre-school years.

The modal age at first presentation for combined amblyopia was <1 year. The most likely explanation for this is that the multiple amblyogenic factors in combined amblyopia cause a more severe amblyopia and when combined with a visible manifestation (like squint or cataract), would cause the parent or guardian to seek medical care early. Woldeyes *et al*[10] in Ethiopia found an overall median age of 7 years which is relatively close to this study (9 years).

The overall mean age at first diagnosis of 8.19 years in this study is comparable to Menon *et al*[14] in India (7.97 ± 6.18 years), and Sapkota *et al*[9] in Nepal (7.74 ±2.97 years). In sharp contrast, the mean presenting age for Chua *et al*[12] in Australia was 32.9 months (≈2.7 years) and 4.0 years for Woodruff *et al*[15] in United Kingdom. These are countries with relatively good health and referral systems resulting in earlier diagnosis. Additionally, United Kingdom is known to have established pre-school vision screening programmes.

Depth of amblyopia: This study found moderate amblyopia (<0.7 LogMAR BCSVA) to be more common (58.47%) than severe amblyopia (≥0.7 LogMAR

BCSVA). This can be explained by the fact that the most common amblyogenic factor was refractive which is known to cause a milder amblyopia than strabismic or sensory deprivation[1].

A breakdown of type versus depth of amblyopia found that most refractive amblyopia (65.86%) was moderate [p-value 0.00] while most pure sensory deprivation amblyopia (64.29%) and pure strabismic amblyopia (57.14%) were severe [p-value 0.04 and 0.01 respectively]. Menon *et al*[14] had similar findings in that the BCSVA in the amblyopic eye showed a significant association with the diagnosed subtype of amblyopia ($p<0.001$). Additionally, the proportion of severe amblyopia (41.53%) in this study is similar to those found by Sapkota *et al*[9] (40%).

For combined amblyopia, the difference between moderate (41.67%) and severe (58.33%) amblyopia was not statistically significant. Combined amblyopia is therefore just as likely to cause deep amblyopia as it is likely to cause moderate amblyopia. This is probably due to the wide variability that can be obtained with different combinations of the amblyogenic factors.

Depth of amblyopia could not be established in 97 eyes (21.51%) because they had a qualitative assessment of amblyopia. This is similar to Woodruff *et al*[15], where 20% had qualitative assessment of amblyopia. In the Woldeyes *et al*[10] study, 8.3% of patients had a qualitative amblyopia assessment.

Catchment area: The children came from the Western and North-Western parts of Kenya with the highest proportion coming from Kisumu county followed by Kakamega and Vihiga counties. These are therefore the areas that could be initially targeted when initiating a pre-school vision screening programme. Most of the counties listed are largely rural and therefore there may be a challenge in accessibility to specialized paediatric eye care.

STUDY LIMITATIONS

The retrospective study design is a limitation as it is dependent on availability of files, as well as accuracy and completeness of record keeping.

CONCLUSIONS

The burden of amblyopia at Sabatia Eye Hospital is estimated to be 6.3%. Refractive amblyopia is the most common type, has a late diagnosis, and was predominantly due to ametropia which is bilateral. Moderate amblyopia is more common than deep amblyopia, and is predominantly due to refractive errors. The patients came from the Western and North-Western parts of Kenya.

RECOMMENDATIONS

There is need to standardize amblyopia case definitions for the purposes of comparison among various studies. Pre-school vision screening programmes are recommended for early diagnosis and timely treatment of refractive errors.

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REFERENCES

1. Skuta G, Cantor L, Weiss J, Raab E, Aaby A, Bloom J, *et al.* American Academy of Ophthalmology (AAO) Basic and Clinical Science Course. Pediatric Ophthalmology and Strabismus. Section 6. 2012 -2013. Canada. Lifelong Education for the Ophthalmologist. 2012. P61-69.
2. Holmes J, Lazar E, Melia M, William F, Dagi L, Donahue S, *et al.* Pediatric Eye Disease Investigator Group. Effect of age on response to amblyopia treatment in children. *Archives Ophthalmol.* 2011; **129**(11): 1451-1457.
3. Pediatric Eye Disease Investigator Group (Scheiman M, Hertle R, Beck R, Edwards A, Birch E, Cotter S, et al). Randomized trial of treatment of amblyopia in children aged 7 to 17 Years. *Archives Ophthalmol.* 2005; **123** (4): 437-447.
4. Woodruff G, Hiscox F, Thompson JR, Smith LK. Factors affecting the outcome of children treated for amblyopia. *Eye.* 1994; **8** (6): 627-631. doi: 10.1038/eye.1994.157
5. United Kingdom National Screening Committee. The UK NSC recommendation on Vision defects screening in children. Last review December 2013. http://www.screening.nhs.uk/vision-child
6. American Association for Pediatric Ophthalmology and Strabismus (AAPOS). Vision Screening Recommendations. http://www.aapos.org//client_data/files/2014/1076_aapos_visscreen.pdf
7. Njambi L, Kariuki M, Masinde MS. Ocular findings in children attending occupational therapy clinic at Kenyatta National Hospital. MMed Ophthalmology thesis. University of Nairobi. 2008.

8. Kalua K, Masinde MS, Njuguna MW. Strabismus as seen in children at University of Nairobi, Kenyatta National Hospital. MMed Ophthalmology thesis. University of Nairobi. 2002.
9. Sapkota K, Pirouzian A, Matta NS. Prevalence of amblyopia and patterns of refractive error in the amblyopic children of a tertiary eye care center of Nepal. *Nepalese J Ophthalmol.* 2013; **5**(9): 38-44.
10. Woldeyes A, Girma A. Profile of amblyopia at the Pediatric Ophthalmology Clinic of Menelik II Hospital, Addis Ababa. *Ethiopian J Health* Develop. 2008; **22**(2): 201-205 doi: 10.4314/ejhd.v22i2.10073.
11. Mehari ZA. Pattern of childhood ocular morbidity in rural eye hospital, Central Ethiopia. *BioMed Central (BMC) Ophthalmol.* 2014; **14**: 50.
12. Chua B, Johnson K, Martin F. A retrospective review of the associations between amblyopia type, patient age, treatment compliance and referral patterns. *Clin Experimental Ophthalmol.* 2004; **32**(2): 175–179.
13. Sharma P, Maitreya A, Dhasmana R. Clinical profile of amblyopia in children in a tertiary care centre, Uttarakhand. *Uttaranchal J Ophthalmol.* 2013; **8**(1):32-37 http://www.uksos.org/yahoo_site_admin/assets/docs/CLINICAL_PROFILE_OF_AMBLYOPIA_1.95220409.pdf
14. Menon V, Chaudhuri Z, Saxena R, Gill K, Sachdev MM. Profile of amblyopia in a hospital referral practice. *Indian J Ophthalmol.* 2005; **53**(4): 227-234.
15. Woodruff G, Hiscox F, Thompson JR, Smith LK. The presentation of children with amblyopia. *Eye* (London). 1994; **8** (6): 623–626.
16. Ganekal S, Jhanji V, Liang Y, Dorairaj S. Prevalence and etiology of amblyopia in Southern India: Results from screening of school children aged 5–15 years. *Ophthalmic Epidemiol.* 2013; **20**(4): 228–231.
17. The Multi-Ethnic Pediatric Eye Disease Study Group (Varma R, Deneen J, Cotter S, Paz S, Azen S, Tarczy-Hornoch K, Zhao P, *et al.*) The Multi-Ethnic Pediatric Eye Disease Study: Design and Methods. (MEPEDS). *Ophthalmic Epidemiol.* 2006; **13**: 253–262.
18. Friedman D, Repka M, Katz J, Giordano L, Ibironke J, Hawse P, Tielsch J. 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): 2128–34.e1-2.
19. Høeg TB, Moldow B, Ellervik C, Klemp K, Erngaard D, la Cour M, Buch H. Danish Rural Eye Study: the association of preschool vision screening with the prevalence of amblyopia. *Acta Ophthalmol.* 2014 doi: 10.1111/aos.12639
20. Chia A, Dirani M, Chan Y, Gazzard G, Kah-Guan Au Eong, *et al.* Prevalence of amblyopia and strabismus in young Singaporean Chinese children. *Invest Ophthalmol Visual Sci.* 2010; **51**(7): 3411–3417.