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Prevalence and Causes of Amblyopia among children aged 3 – 15 years attending Usmanu Danfodiyo University Teaching Hospital, Sokoto State, Nigeria

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ABSTRACT

Background: Amblyopia is a condition that can result from visual deprivation in early childhood. It is a major cause of impaired vision in infants and young children.

Objective: The purpose of this study was to determine the prevalence, laterality and causes of amblyopia among children in Sokoto State, Nigeria.

Methods: This study was a hospital-based, cross-sectional study of children aged 3-15 years, presenting at the Ophthalmology clinic, Usmanu Danfodiyo University Teaching Hospital (UDUTH), Sokoto State, Nigeria between January-June, 2022. Socio-demographics data were collected using questionnaire. Comprehensive eye examination were determined using paediatric Snellen charts, retinoscope and direct ophthalmoscope. Amblyopia was defined as two or more Snellen lines difference in the Best Corrected Visual Acuity (BCVA) between the two eyes, or a BCVA of less than 6/12 bilaterally in the absence of any significant organic lesion that could result in a decrease in vision. Data collected were analyzed using SPSS version 26.0. Statistically significant at 95% confidence level were considered at $P<0.05$.

Results: Of a total 108 children with mean age of 8.69 ± 3.75 standard deviation, males 59 (54.6%) were slightly higher than females 49 (45.4%). The prevalence of amblyopia was 12.9% (14), of which 64.3% and 35.7% had unilateral and bilateral amblyopia respectively. Sensory deprivation (42.9%) was the main cause of amblyopia.

Conclusion: The high prevalence of amblyopia can lead to severe visual impairment in later life if appropriate measure is not taken early. Increase awareness on the need for early detection and correction of amblyopia will help ameliorate this burden.

Key words: Amblyopia, Sensory Deprivation, Anisometropia, Ametropia, Tropia

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1: INTRODUCTION

1.1: Background

During the crucial stages of visual development, amblyopia emerges early in life. It is characterized by a reduction in visual acuity in one eye due to abnormal binocular interaction or as a result of pattern vision deprivation in one or both eyes during vision immaturity, for which a physical examination of the eye or eyes is unable to identify the cause and, in certain situations, can be treated with therapy (Von Noorden and Campos, 2002). In the absence of any evident anatomical abnormalities, amblyopia, also known as "lazy eye," is a unilateral or rarely bilateral disorder in which the best corrected visual acuity is less than 20/20 (Ciuffreda et al., 1991). Amblyopia was equally defined as a condition in which reduced visual acuity exists, even with the best corrective lenses, without an obvious cause. Although amblyopia can occur as a result of a wide variety of conditions including various forms of toxicity and extreme malnutrition, when optometrists speak of amblyopia, they most often mean functional amblyopia (El Byoumi and Mousa, 2010; Gilbert and Ellwein 2008). This loss of visual acuity ranges from slightly worse than normal (6/6) to functionally blind (6/60 or worse). The latter only develops in children up to the age of 6-8 years, although it may persist for life once established (Grosvenor, 2007). The brain may "learn" to disregard the retinal image of one eye, which could result in suppression, if there is a significant discrepancy in the refractive states of the two eyes, or if one eye deviated inward, outward, upward, or downward relative to the other. Prolonged suppression may eventually lead to amblyopia ex anopsia, or "amblyopia from non-use," which is characterized by reduced visual acuity in the more ametropic or deviated eye (Grosvenor, 2007). When reading a single optotype rather than a row of letters, people with amblyopia typically have higher visual acuity (VA) due to the crowding phenomenon. In addition to VA, other monocular visual functions that are impacted are contrast sensitivity, Vernier acuity, and grating acuity. In addition to having poor accommodation, amblyopic eyes can also show signs of ocular motor deficiencies, such as shaky fixation and uneven tracking. Along with academic disabilities, children who have amblyopia may also experience repeated injuries from bumping into things on the side of their amblyopic eye. Because people with amblyopia are more likely to damage their good eye and experience function loss when this happens, lowering the rate of amblyopia can lessen the degree of bilateral vision loss (Bezabih et al., 2017; Da Silva et al., 2023).

Based on the clinical circumstances leading to its development, amblyopia can be divided into three categories: functional amblyopia, strabismic amblyopia, and refractive amblyopia. This classification is a useful tool for determining the cause of the problem and implementing effective management techniques. Before the age of 6 to 8 years old, functional amblyopia can be caused by anisometropia, strabismus, or form deficiency (Dorn and Petrinović-Dorešić, 2007; Ghaderi et al., 2018). According to Grosvenor (2007) functional amblyopia includes strabismic, refractive, and hysterical (psychogenic) amblyopia. Long-term suppression of strabismic patients may result in strabismic amblyopia in the deviated eye. The strabismic eye's visual acuity can range from 6/60 (20/200) to 6/7.5 (20/25). When reading the letters on the Snellen acuity chart, a non-amblyope usually reads every letter in each line until they reach a point where they are unable to discern some or all of the letters in that line. The amblyope, on the other hand, frequently reads one or two letters in each of multiple lines, making it challenging to determine visual acuity. This phenomena is known by several names, including separation difficulty, the crowding phenomenon, and

contour interaction (Grosvenor, 2007; Parrey, 2019; Ferede et al., 2020). Due to the phenomena of contour interaction, the visual acuity for an amblyopic eye fluctuates with the amount of stimuli present on the acuity chart. Visual acuity may be somewhat poor if a chart including numerous lines of letters is displayed, but has been proven to improve if a single line of letters is presented, and improves more if single letters are presented (Akujobi, 2020; Da Silva et al., 2023; Grosvenor, 2007). Therefore, the "whole chart" approach of measuring visual acuity should be employed in a routine vision screening of children. Amblyopia patients might go unnoticed otherwise. Hyperopia, myopia, and astigmatism are examples of untreated refractive abnormalities that can lead to refractive amblyopia. When one eye is significantly more hyperopic than the other (e.g., right eye +4.00D and left eye +1.00D), the less hyperopic eye must accommodate less for vision at all distances, hence the more hyperopic eye will never perceive a highly focused retinal image. Amblyopia results from the more hyperopic eye's regular suppression. A child who has a significant amount of uncorrected astigmatism (2.00 or 3.00D or more) may develop amblyopia in both eyes as a result of neither eye being able to see a perfectly sharp retinal image. However, this amblyopia usually only affects a tiny portion of the population, with corrected visual acuity of roughly 6/9 (or 20/30). If corrective lenses are supplied during the school years, the patient's eyesight usually gradually improves. It is often recommended to correct hyperopia and anisometropia in infants and early children because uncorrected hyperopia can lead to esotropia and anisometropia (London and Wick, 2006).

For the purpose of this study amblyopia is defined as difference in the Best Corrected Visual Acuity (BCVA) between the two eyes, of two or more Snellen lines or its equivalent in the absence of any significant organic lesion that could result in a decrease vision or a BCVA of less than 6/12 bilaterally on the Snellen chart or its equivalent in the absence of any significant organic lesion that could result in a decrease in vision. Mild amblyopia is often classified as being visual acuity of 6/9 to 6/12 (Williams, 2009). BCVA of 6/12 to 6/36 in the amblyopic eyes is classified as mild to moderate amblyopia and BCVA ≤6/60 as severe amblyopia (Varma et al., 2006).

1.2: Statement of the problem

The prevalence of amblyopia in children and teenagers varies between 0.20 and 6.2% worldwide. (Carlton et al., 2008; Alarepe et al., 2017). The differences may arise from differences in the way diseases are classified and the study designs used. This complicates direct inter-survey comparability (Alarepe et al., 2017; Hashemi et al., 2018). In Nigeria, the majority of school-based surveys have concentrated on children's refractive errors, visual impairment, and ocular health (Ajaiyeoba et al., 2007; Okoye et al., 2013; Olowoyeye et al., 2018). Unfortunately, there is a dearth of disorder-specific information on amblyopia in children living in Sokoto State and other parts of Northern Nigeria.

Children with amblyopia may not be aware of or complain of their impaired vision. Therefore, screening programs are necessary to support early detection and treatment of amblyopia (Ikuomenisan et al., 2016). A lack of early detection of moderate-to-severe visual impairment especially due to amblyopia has been linked to poor academic performance in school-age children. As a result, these children miss out on important opportunities for their physical, mental, and educational development (Alarepe et al., 2017).

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Despite the availability of effective treatments, including patching, atropine eye drops, and corrective lenses, there remains a challenge in ensuring timely identification and adherence to treatment protocols. Barriers to treatment adherence include the discomfort associated with patching and the social stigma children may face while undergoing treatment (Stewart et al., 2004). If amblyopia is not identified and treated in its early stages, it can result in permanent vision loss that could have been prevented (Ikuomenisan et al., 2016; Moyegbone et al., 2020).

1.3: Study objectives

This study aimed to investigate the prevalence and causes of amblyopia in Usmanu Danfodiyo University Teaching Hospital, Sokoto State, Nigeria in order to develop strategies for the early detection and treatment of amblyopia. The specific objectives are to:

1. Evaluate the prevalence of amblyopia among children aged 3-15 years in Usmanu Danfodiyo University Teaching Hospital, Sokoto State, Nigeria
2. Identify the classes of amblyopia among children aged 3-15 years in Usmanu Danfodiyo University Teaching Hospital, Sokoto State, Nigeria
3. Determine the causes of amblyopia among children aged 3-15 years in Usmanu Danfodiyo University Teaching Hospital, Sokoto State, Nigeria

2: MATERIALS AND METHODS

2.1: Ethical clearance and study performance site

This study was performed as part of Residency Training research work at the Faculty of Paediatric Optometry, Nigerian Postgraduate College of Optometrists. Ethical approval was sought and obtained from the Health Research Ethics Committee of Usmanu Danfodiyo University Teaching Hospital (UDUTH), Sokoto, Nigeria as well as the ethics committee of the Nigerian Postgraduate College of Optometrists. This study adhered to the tenets of the Declaration of Helsinki for research involving humans. Written informed consent was obtained from the parents or guardians; while assent was sought from each child prior to examination. No child was coerced into participating in this study. Participant had the freedom to withdraw from the study at any point.

2.2: Research design

The study was a hospital-based cross-sectional descriptive study among new and follow up patients aged 3 to 15 years diagnosed with amblyopia in the ophthalmology clinic of Usmanu Danfodiyo University Teaching Hospital, Sokoto State, Nigeria from January to June, 2022.

2.3: Study participants and data collection

Children within the ages of 3 and 15 years whose parents/guardians gave consent to participate in the study and the cause of poor vision was not attributable to ocular pathology were included in the study. Children that do not meet the inclusion criteria were excluded.

The minimum sample size for this study was estimated using the formula.(Charan and Biswas, 2013)

$$n = \frac{Z^2 p(1-p)}{e^2}$$

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Where;

n is the desired sample size (when population is >10,000)

Z is the abscissa of the normal curve that cuts off an area α at the tails (1 - α equals the desired confidence level, e.g., 95%) which is 1.96.
e is the desired level of precision (degree of accuracy) which is 7% (0.07)
p is the estimated proportion of an attribute that is present in the population which is taken as 12.9% from a previous study in Nigeria,(Alarape et al., 2017)
q is 1-p, i.e (1-0.129).

$$n = \frac{1.96^2 x\ 0.129 \text{ x } (1-0.129)}{0.07^2}$$

n = 88 persons

Non-response rate or attrition of 10% = approximately 9 persons

Therefore, minimum sample size is 97 participants.

A total of 108 new and follow up children out of the 154 children who visited the Ophthalmology clinic of Usmanu Danfodiyo University Teaching Hospital, Sokoto State, Nigeria from January to June, 2022, and who meet the inclusion criteria were recruited into the study. The inclusion criteria was children with poor visual acuity that was not improved with glasses, and that was not attributable to any structural abnormalities. Ophthalmic nurses and community health extension workers were recruited as research assistants to assist in administration of questionnaires and visual acuity measurement. The research assistants were adequately trained to avoid bias. A pilot study was carried out in the hospital. Ten percent of the calculated sample size i.e. 10 patients (5 new and 5 follow up) were selected outside the area of study. The training of the research assistants was perfected through this pilot study, and the questionnaire used for the data collection was pre-tested, modified accordingly and validated by a consultant Pediatric Optometrist, Nigerian Postgraduate College of Optometrists. All new and follow up patients seen during the study period, who fulfill the study criteria were recruited into the study and a structured interviewer-administered questionnaire i.e. it was administered to them by the principal investigator. The patients or their parents/guardians answered the questions raised in the questionnaire. The questionnaire details are information on child's age, sex, ethnicity, etc.

2.3.1: Clinical Assessment for amblyopia

Assessments of distance visual acuity (VA) in each eye was done separately, using an age-appropriate Snellen visual acuity chart. The unaided visual acuity (UAVA) was assessed for each eye of every patient and aided visual acuity was performed on those who wore spectacles. Patients with UAVA < 6/6 were subjected to pinhole VA evaluation, followed by noncycloplegic retinoscopy and subjective refraction. Cycloplegic refraction was done on all children less than 10 years and subjective refraction subsequently to obtain the Best Corrected Visual Acuity (BCVA). Pupillary dilation was achieved with the aid of 1.0% cyclopentolate eye drops, two drops 5 minutes apart. The patient kept both eyes closed for 30-45 minutes. Full pupillary dilation was expected to

be attained for cyclorefraction. Dilated funduscopy was carried out with the aid of direct Ophthalmoscope. The anterior segment examination was done with the aid of a direct ophthalmoscope.

A streak retinoscope (Heine) was used for objective refraction. Patients with two or more optotypes lines difference of BCVA between the eyes or BCVA ≤6/12 in both eyes were subjected to single optotypes visual acuity (amblyopic) chart to establish VA without crowding phenomenon effect.

General facial appearance in a well illuminated room and ocular alignment were evaluated with Hirschberg cornea light reflex, cover-uncover test at far (6m) and near (40cm) distances and Krimsky test to quantify the degree of deviation. The extraocular motility in all directions of gaze were assessed. Pupillary reactions, both direct and consensual, in a dimly illuminated room and near reflexes were evaluated using a pen-torch.

2.3.2: Classification and Definitions of amblyopia

Strabismic amblyopia is defined as amblyopia in the presence of a heterotropia at distant or near fixation, in the absence of any anisometropia meeting the criteria for a combined mechanism amblyopia or patient with strabismus along with refractive errors of less than 1D spherical equivalent (SE) in one or both eyes with regular astigmatism < 1.5D in any meridian.

Anisometropic amblyopia is defined as amblyopia in the presence of anisometropia that is ≥1D SE or ≥1.5D difference in astigmatism between both eyes. Combined amblyopia is heterotropia at distance or near along with anisometropia of 1D or more in SE or >1.5 difference in astigmatism in any meridian between both eyes (Alarape et al., 2017).

Sensory deprivation amblyopia is those with a known cause of sensory deprivation (media opacity) with no primary heterotropia or refractive errors that could be causally related to the amblyopia (Alarape et al., 2017).

Ametropic amblyopia is defined as patients with refractive errors >1D SE in both eyes resulting in subnormal vision in one or both eyes and no associated strabismus, anisometropia or any other significant ocular pathology (Alarape et al., 2017).

Meridional amblyopia is defined as patients with regular astigmatism of 1.5D or more in any meridian or those with irregular astigmatism in both eyes, resulting in a decrease in vision in one or both eyes and no associated strabismus or anisometropia.(Alarape et al., 2017).

2.4: Statistical analysis

Data collected were entered in Microsoft Excel 2016, and then, imported into Statistical Package for Social Sciences for windows, version 26.0 (SPSS Inc, Chicago, III, USA) for statistical analysis. Categorical variables such as gender and level of education were reported with frequency and percentage. Normally distributed continuous data were reported with mean ± standard deviation, while skewed data was reported with median and interquartile range. The association between the outcome variable (amblyopia) and explanatory variables was tested with Chi-square test or Fisher's exact test, where applicable. All reported p-values were two-tailed and P <0.05 was considered statistically significant.

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3: RESULTS

3.1: Overview

Out of the 154 children who visited the Ophthalmology clinic, Usmanu Danfodiyo University Teaching Hospital, Sokoto State, Nigeria from January to June, 2022, aged between three and fifteen years, 108 children met the inclusion criteria and were recruited into the study. While the remaining 46 children had improved visual acuity with pinhole evaluate. Hence, they were excluded from the study.

The mean age of the 108 children examined was 8.69 ± 3.75 standard deviation, with the mean age of males being 8.71 ± 3.82 standard deviation and that of females being 8.67 ± 3.7 standard deviation. In this study, age and sex were not statistically significant, with p-value of 0.383 and 1.000 respectively.

In Table 1, the number of male children in the study were slightly higher than that of females. Children within the age range of six to ten have the highest number, while the least number are those between three and five years of age.

Table 1: Child's sociodemographic characteristics

Variables	Options	Frequency (N = 108)	Percent (%)
Gender	Male	59	54.6
	Female	49	45.4
Age (Years)	3- 5	26	24.1
	6-10	45	41.7
	11-15	37	34.2
Ethnic group	Hausa/Fulani	78	72.2
	Yoruba	9	8.3
	Igbo	8	7.4
	Others	4	3.7
	No response	9	8.3
Household number	1-7	68	63.0
	>7	29	26.9
	No response	11	10.2

3.2: Results for specific objective 1

Among the 108 children examined during the specified period, 14 children with amblyopia between the ages of 3 and 15 years were identified, resulting in a prevalence of 12.96% as shown in figure 1. The mean age of the 14 children who were amblyopic was 10.57 ± 3.97 standard deviation, of which, the prevalence of amblyopia was higher in male children than in female children with prevalence of 57.1% and 42.9% respectively.

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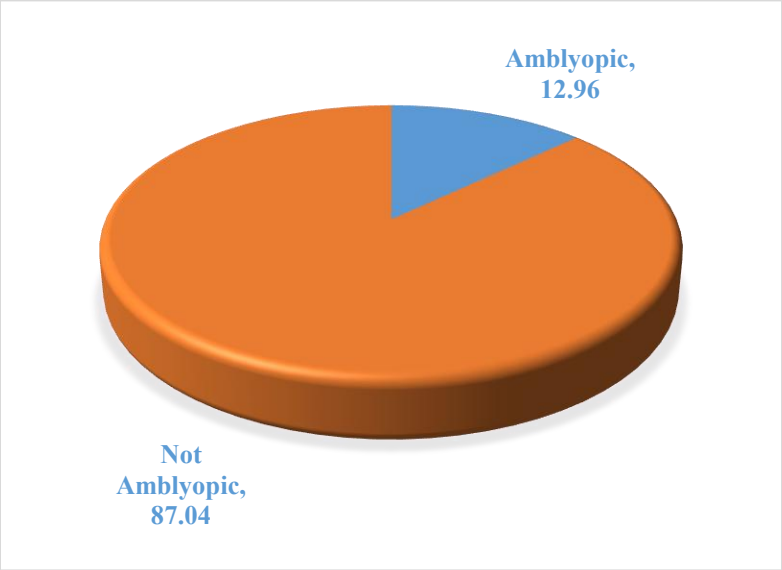

Fig 1: Prevalence of amblyopia

3.3: Results for specific objective 2

Figure 2 shows the percentage categories of amblyopia. It is clear that half of the children with amblyopia had severe amblyopia, followed by moderate amblyopia. Minority of the children had mild amblyopia. In Figure 3, almost two-third of the children had unilateral amblyopia, while the remaining one-third had bilateral amblyopia.

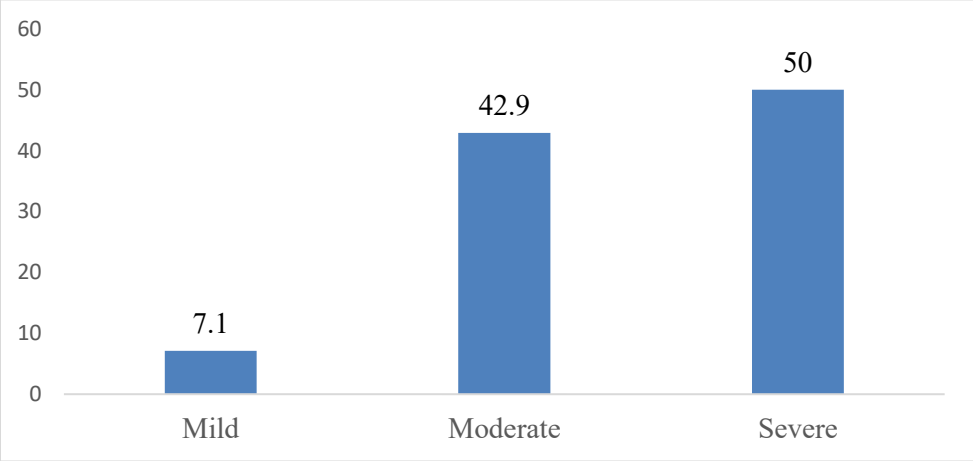

Fig 2: Percentage categories of amblyopia

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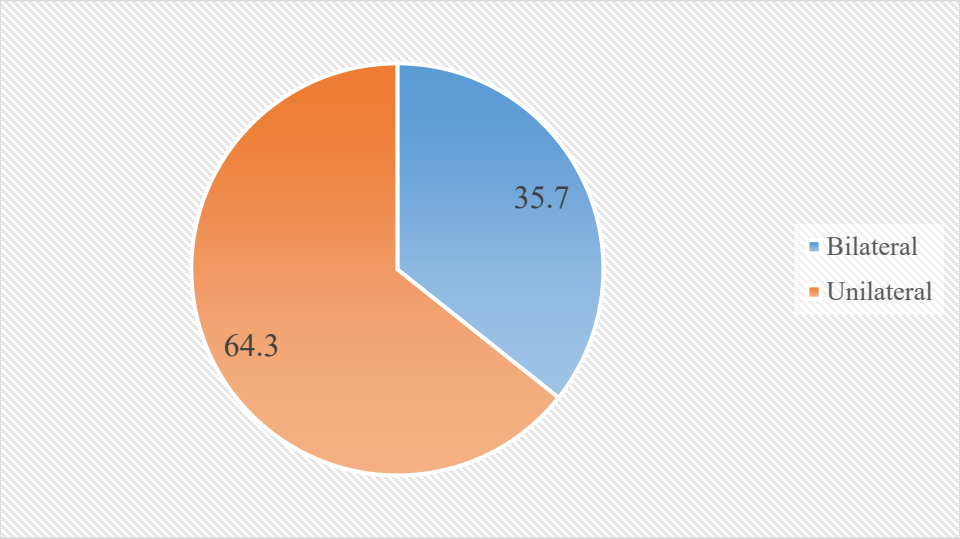

Fig 3: Laterality of amblyopia

3.4: Results for specific objective 3

Figure 4 showed the causes of amblyopia. Sensory amblyopia was the major cause of amblyopia in the right eye, while combined amblyopia was the main cause of amblyopia in the left eye.

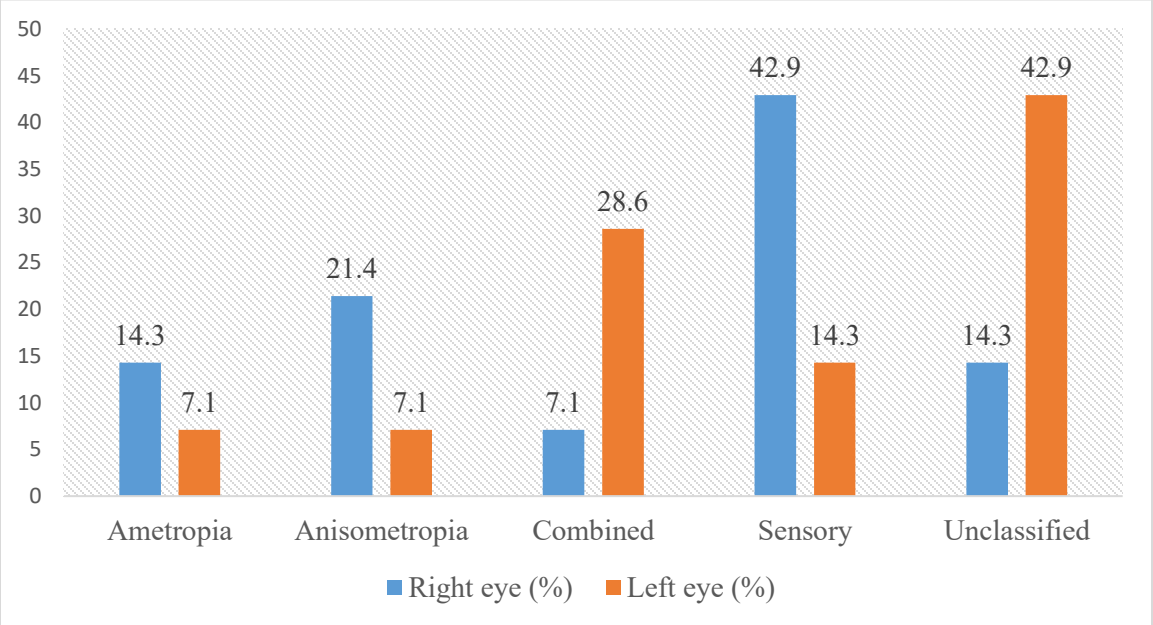

Fig 4: Causes of amblyopia

Combined = Combined sensory deprivation, strabismic and ametropic/refractive amblyopia

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4: DISCUSSION

4.1: Overview

Amblyopia, commonly known as "lazy eye," is a neurodevelopmental visual disorder that typically manifests in early childhood. It is characterized by reduced vision in one eye that is not attributable to any structural abnormalities but arises from abnormal visual experience during the critical period of visual development (Birch, 2013). Amblyopia affects approximately 2-3% of the pediatric population, making it a significant public health issue (Holmes and Clarke, 2006). The primary causes of amblyopia include strabismus, anisometropia, and deprivation due to conditions such as cataracts (Wallace et al., 2011) or ptosis (Tekle-Giorgis and Bejiga, 2001). Early diagnosis and intervention are crucial, as the efficacy of treatment decreases with age. Untreated amblyopia can lead to permanent visual impairment and has been associated with reduced quality of life and difficulties in academic and social settings (Rahi et al., 2002).

4.2: On the first specific research objective

A total of 108 children were recruited into the study, and 14 were found to have amblyopia, giving a prevalence of 12.9%. This is similar to the results of a hospital-based study done by Woldeyes and Girma (2008) at the paediatric ophthalmology clinic of Menilik II Hospital, Addis Ababa, where a 9.1% prevalence was found. This is also comparable to a 12.0% prevalence found by Akujobi (2020) in a population-based study in Imo state, Nigeria. The result of this study was higher than the prevalence of 4.2% among school-aged children in Enugu State (Chibueze et al., 2019) and 0.5% in Southwestern Nigeria (Alarepe et al., 2017). The prevalence of this study is also higher than the prevalence of 2.6% (Ovenseri-Ogomo and Adofo, 2011) in Ghana; 1.5% to 3% among African American children (Varma et al., 2006); 1.4% found by Bhandari *et al*. (2015) at the Department of Pediatric Ophthalmology, Bharatpur Eye Hospital; 4.4% found by Murthy *et al.* (2020) at New Delhi, India, 6.5% in Ethiopia (Tegegne et al., 2021) and the world amblyopia prevalence of 1.36% (Hu et al., 2022). According to Hu *et al*. (2020), socio-economic status of the continents is a major cause of variation in prevalence of amblyopia, leading to different access to screening. Poor resource settings in the Northern part of Nigeria in which there is lack or inadequate access to routine pediatric eye care services and screening may contribute largely to the regional variations in prevalence of amblyopia (Hashemi et al., 2018). Poverty is another factor that may limit access to healthcare facilities where it is available in the area of study with resultant delays in early diagnosis and treatment, leading to higher prevalence rates and more severe cases of untreated amblyopia. Moreover, differences in how studies were conducted, including criteria for diagnosing amblyopia, sample sizes and methodologies may contribute to these variations (Hashemi et al., 2018).

4.3: On the second objective

Severe amblyopia was found in this study to be the most common category of amblyopia with a prevalence of 50%. Moreover, 42.9% had moderate amblyopia, and 7.1% had mild amblyopia. Contrary to this study, Wanyonyi *et al.* (2018) found moderate amblyopia with a prevalence of

58.47% to be the most common category of amblyopia. The prevalence of mild, moderate and severe amblyopia reported in this study was far higher than the prevalence of 3.9%, 2.7% and 0.3% for mild, moderate and severe amblyopia respectively as reported among school aged children in Nigeria (Eze et al., 2024). Also, the prevalence of mild, moderate and severe amblyopia respectively was reported among school-aged children to be 1.5%, 0.8%, and 0.4% in Ghana (Ovenseri-Ogbomo & Assien, 2010), 2.6%, 1.2% and 0.6% in America (Varma et al., 2006), as well as 2.0%, 1.2% and 0.3% in Europe (Williams et al., 2003).

This study also found 64.3% children with unilateral amblyopia and 35.7% children with bilateral amblyopia. This is in agreement with the result of the study carried out by Gupta *et al*. (2019) who found that the number of children with unilateral amblyopia (87.9%) was more than those with bilateral amblyopia (12.1%). Several researchers had reported the prevalence of bilateral amblyopia to be less frequently reported but estimated to be lower than unilateral amblyopia (Tegegne et al., 2021; Chibueze et al., 2019; Alarepe et al., 2017). Contrary to this result, study done by Wanyonyi *et al.* (2018) showed that most of the amblyopic patients had bilateral amblyopia with prevalence of 68.28%, while only 31.72% had unilateral amblyopia.

4.4: On the third and last objective

The main cause of unilateral amblyopia found in this study was sensory amblyopia (42.9%), followed by combined amblyopia (28.6%), anisometropic amblyopia (21.4%), and ametropic amblyopia (14.3%). This was inconsistent with the study carried out by Woldeyes & Girma (2008) and Wanyonyi *et al*. (2018), who found the most common cause of amblyopia to be Strabismic amblyopia and Refractive amblyopia respectively. The primary causes of amblyopia in Ghana include refractive errors, strabismus, and visual deprivation from conditions such as congenital cataracts (Asare et al., 2020). Meanwhile, strabismus, anisometropia, and visual deprivation due to cataracts or ptosis were the primary causes of amblyopia in Saudi Arabian (Challa, 2022) and American (Wallace et al., 2011) children. In India, the primary causes of amblyopia in children was reported to include refractive errors, strabismus, and visual deprivation due to conditions such as congenital cataracts (Murthy et al., 2002).

5: CONCLUSION AND RECOMMENDATIONS

This study revealed a significant prevalence of amblyopia (12.96%). Amblyopia was mostly caused by sensory deprivation, with ametropia and anisometropia coming in second and third. Compared to bilateral amblyopia, unilateral amblyopia is more common in children, and half of those with amblyopia had severe amblyopia. This study is limited to the children who presented at the pediatric ophthalmology clinic, UDUTH, Sokoto State, Nigeria. Hence findings cannot be generalized to other states in Nigeria or other countries. In order to lessen the burden of visual impairment in later life, it is therefore strongly advised that pre-school screening be done on children in order to detect early risk of developing amblyopia. This study was hospital-based. Hence, a population-based study should be done in this area. Going forward, future research on amblyopia should adhere to a universally accepted definition in order to ensure accurate comparisons.

DECLARATIONS

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