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Colour Perception Studies on Students of Nnamdi Azikiwe University Nnewi Campus, Nigeria

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ABSTRACT

BACKGROUND/AIMS: Colour blindness can be frustrating and may limit participation in some occupations. The career choices of colour blind people may be limited for safety reasons. In medical education, colour perception is important in histology, histochemistry, biochemical tests and other colour based assessments. The aim of this study was to evaluate the status of visual colour perception among medical students in Nnamdi Azikiwe University, Nnewi Campus, Nnewi, Nigeria.

MATERIALS AND METHODS: A descriptive cross-sectional study design was carried out between September and October 2019. It was approved by the Faculty of Basic Medical Sciences Ethical Board. Ocular examination including visual acuity assessment using Snellen's chart and a colour vision test with Ishihara 24 plate album was performed on 291 medical students randomly selected for the study. The data collected was analysed.

RESULTS: From the study, it was discovered that the overall prevalence of congenital colour vision deficiency was 1.7% with a male to female ratio of approximately 2:1 respectively.

CONCLUSION: This signifies that early diagnosis is valuable in career and vocational planning in order to reduce any difficulties in living and learning situations associated with colour blindness.

Keywords: Colour blindness, medical, students, vision, Ishihara, Snellen's chart

INTRODUCTION

Visual problems are an important factor that can pose a serious challenge to educational activities in the school, hence good vision is required to achieve optimum results in the learning process. Colour is a visual enhancement element that is important in enriching the learning process.[1]

Colour perception is the ability to distinguish between various wavelengths of light waves and to perceive these differences as differences in hue. The normal human eye can discriminate among hundreds of such bands of wavelengths as they are received by the colour-sensing cells (cones) of the retina. These cones have light sensitive pigments that enable humans to recognize colour. Three types of cones occur in the macula and each contains a distinctive type of pigment which is sensitive to either red, green or blue light (long, medium or short wavelengths) based on their respective wavelengths. A given colour stimulates all three types of receptors with varying effectiveness, and the pattern of these responses determines the colour perceived. Genes contain the coding instructions for the cone pigments, and when the coding instructions are wrong, the wrong pigments will be produced, and the cones will be sensitive to different wavelengths of light resulting in a colour perception deficiency. The colours that we see are completely dependent on the sensitivity ranges of these pigments.

Colour vision deficiency (colour blindness) is the inability to see differences between certain colours that can be generally

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distinguished by normal people.[2] These individuals still recognize colour though it is imperfect.[2] Colour blindness is a sex-linked genetic characteristics affecting more males than females. It occurs due to varied forms of mutation. The gene for colour blindness is recessive and carried on the X-chromosome. Red-green colour vision defects are the most common form of colour vision deficiency, where either the photo-pigment of the red or green cone is absent (Deutranopia or Protanaopia) or where the photo-pigment response of the green cone is shifted towards the red cones (Deuteranomaly) or vice versa (Protanomaly) and it is genetically determined by the X-linked recessive gene.[3] Affected individuals have trouble distinguishing between some shades of red, yellow, and green.

Blue-yellow colour vision defects (also called tritan defects), which are rarer, cause problems with differentiating between shades of blue and green and lead to difficulties in distinguishing dark blue from black. The genes responsible for the red-green colour vision defects are localized on the long arm of the X chromosome at Xq28,[4] whereas the blue pigment gene is located on chromosome 7, an autosome, at 7q32.[5] Green pigment genes vary in number among colour-normal individuals and, together with a single red pigment gene, are thought to reside in a head-to-tail tandem array within the X chromosome.[3] Although colour blindness is a hereditary trait, it has also been reported that some acquired characteristics such as metabolic disorders such as diabetes, sickle cell anaemia, damage to the eyes, nerve and brain; drugs (e.g., digoxin, ethambutols, plaquenil, chloroquine etc); and other chemicals could also predispose one to colour blindness.[6] These two forms of colour vision deficiency disrupt colour perception but do not affect the sharpness of vision (visual acuity).[7] Also, a complete absence of colour vision (total colour blindness), which is rare, may be present.

Colour blindness can be frustrating and may limit participation in some occupations. It can affect access to education, exam grades and career choices.[8] The career choices of colour blind people may be limited in a few areas of industry, transport services and the armed forces. It is accepted that colour blindness could potentially cause problems and it is recognized that there are certain job types in which the colour blind people are not suited to, mostly for safety reasons.[8] Also, colour blindness may pose occupational handicaps in certain areas of medical practice and the health sciences as colour perception is important in histology, histochemistry, biochemical tests and other colour based assessments.

According to Colour Blind Awareness,[9] there is general agreement that, worldwide, 8% (1 in 12) of men and 0.5% (1 in 200) of women have colour blindness. These figures rise in areas such as Scandinavia where there is a greater number of Caucasians per head of population. Countries such as India and Brazil have a relatively high incidence of colour blindness because of the large numbers of people with mixed race genes in their genetic history. By contrast, in sub-Saharan Africa, there are few colour blind people. Studies among some African populations have reported frequencies of 2.2% and 0.0% in males and females respectively in Libya, and 3.3% and 0.2% in males and females of Zulus descent.[10,11] Also, previous studies conducted among school children in the Southern and Northern parts of our country have reported a general prevalence of 2.6% and 1.5%, respectively.[12,13] This study, however, aims to determine the prevalence of congenital colour blindness among Nnamdi Azikiwe University Medical School students.

MATERIALS AND METHODS

Research Design

A descriptive cross-sectional survey was carried out to determine the prevalence of congenital colour blindness among medical students of Nnamdi Azikiwe University, Nnewi Campus between September and October, 2019.

Study Area

Nnamdi Azikiwe University, Nnewi Campus is situated in Okofia; one of the villages that make up Nnewi North Local Government Area, with an estimated population of about 15,000. Its latitude is 5^0 58' 26" North and its longitude 6^0 53' 32" East.

Sample

Two hundred and ninety-one students were randomly selected from the population of the study area.

Inclusion Criteria

Students' willingness to take part in the research, and being a medical student of the Faculty of Basic Medical Sciences were the inclusion criteria.

Exclusion Criteria

Students with previous ocular surgery, and the presence of a colour defect in one eye only were excluded from the study because this defect was acquired.

Instrument for Data Collection

Standard Snellen's chart, Ishihara 24 plates (Dr Shinobu Ishihara - 2017 Edition by Kanehara & Co., LTD), Eye Occluder and Test Form were used.

Ethical Consideration

Ethical approval to carry out this study was obtained from the Ethics Board of the Faculty. Only minimal identifying data was taken in order to preserve the anonymity of the students' responses and results. Prior to the investigation, a written informed consent form was obtained from the students after the procedure was explained to them. Only those who met the inclusion criteria participated in this study.

Procedure

A self-developed test form was used as part of the instrument for the collection of the students' their data on their ocular history, visual acuity and colour perception.

The procedures (for visual acuity and colour vision testing) were explained to the students prior to the examination. An eye occluder was used to occlude the eye not being tested while the other eye was being assessed.

Assessment of visual acuity was performed at a place with good daylight illumination using the standard Snellen's chart at a distance of 6 m. This was done monocularly for both eyes. All students who used spectacles had their visual acuity assessed while wearing their own spectacles. Thereafter, a colour vision test with 20 Ishihara plates was done uni-ocularly in natural daylight with the plates held at a distance of 45 cm. In the 24-plate 2017 edition, plate 1 is a demonstration plate; plates 2 to 17 and 22 to 24 are for screening, while plates 18 to 21 are for illiterates.

The students were asked to read the numerals seen on each plate within 3 secs before moving on to the next plate. Failure of the Ishihara in only one eye is suggestive of an acquired cause of colour vision deficiency, and such students were excluded from this study. Students who failed eight or more plates were considered to be colour blind.

Statistical Analysis

The collected data was entered into Microsoft Excel 2007 (One Microsoft Way Redmond, Washington, USA) and analysed with SPSS version 20 (Chicago, Illinois, USA). A descriptive analysis was performed to calculate the prevalence and percentage of occurrence. The analysed data are presented in Tables 1-4 and Figures 1 and 2.

RESULTS

A total of 291 students participated in the study consisting of 128 males and 163 females.

Table 1. Prevalence of known vision defect

Vision defect	Gender		Total
	Male, n (%)	Female, n (%)	n (%)
Yes	19 (14.7)	39 (23.9)	58 (19.9)
No	109 (85.2)	124 (76.1)	233 (80.1)
Total	128 (100)	163 (100)	291 (100)

n: number of the students.

14.7% of the males (n=19) and 23.9% of the females (n=39) have a known vision defect. The total number of students that have a known vision defect being 58 (19.9%), while 233 (80.1%) of students do not have any known vision defect.

The majority of the students (male: n=123, female: n=152) are aware of the term 'colour blindness'.

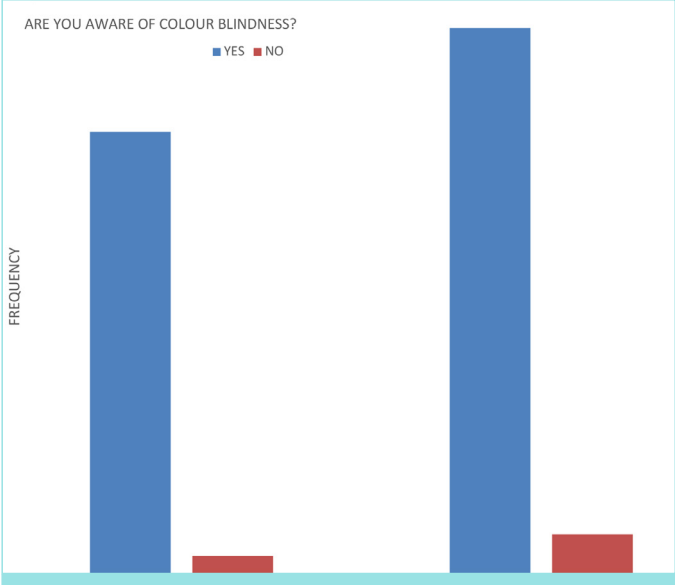

Figure 1. Distribution of students that are aware of the term 'colour blindness'.

Table 2. Distribution of students aware and those not sure of having colour blindness

	Gender		Total
	Male, n (%)	Female, n (%)	n (%)
Yes	2 (1.6)	0 (0)	2 (0.7)
No	101 (78.9)	123 (75.5)	224 (77)
Do not know	25 (19.5)	40 (24.5)	65 (22.3)
Total	128 (100)	163 (100)	291 (100)

n: number of the students.

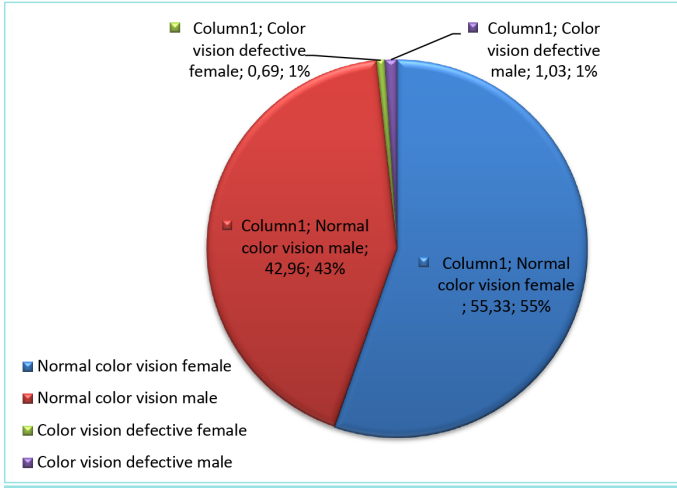

Figure 2. Prevalence of normal/defective colour vision in the population.

Majority of the students (n=224, 77%) indicated that they do not have colour blindness. Whereas 65 (22.3%) do not know if they are colour blind or not, none of the female respondents accepted being colour blind. However, two of the males knew that they have colour blindness.

One hundred and forty-four (49.5%) of the students have a normal visual acuity of 6/6 in the right eye, 137 (47.1%) in the left eye, while 121 (41.6%) have visual acuity of 6/6 when using both eyes. No male/female had visual acuity of 6/36 when both eyes were examined together. Therefore, the majority of the students including the colour blind ones have normal visual acuity.

Two hundred and eighty-six students representing 98.3% were found to have normal colour vision while only five students (1.7%) were found to have colour vision deficiency. As indicated in Table 3, colour blindness in our subjects occurs independently of visual acuity and other vision defects (myopia, hypermetropia and so on).

From the population, 2.34% and 1.23% of the male study population and female study population respectively have colour blindness, while 97.66% and 98.77% of male population and female study population respectively do not have colour blindness.

DISCUSSION

Colour blindness is a naturally challenging vision defect which can significantly affect quality of life and career choices of individuals. This study provides a description of colour vision deficiency in the study area for the first time among medical students of Nnamdi Azikiwe

Table 3. Result of visual acuity

Visual acuity	Right eye		Left eye		Both eyes	
	Male, female n (%)	Total	Male, female n (%)	Total	Male, female n (%)	Total
6/36	1 (0.8), 0 (0)	1 (0.3)	1 (0.8), 0 (0)	1 (0.3)	0	0
6/24	1 (0.8), 5 (3.1)	6 (2.1)	0 (0), 3 (1.8)	3 (1)	1 (0.8), 1 (0.6)	2 (0.7)
6/18	3 (2.3), 2 (1.2)	5 (1.7)	3 (2.3), 2 (1.2)	5 (1.7)	0 (0), 1 (0.6)	1 (0.3)
6/12	4 (3.1), 7 (4.3)	11 (3.8)	1 (0.8), 4 (2.5)	5 (1.7)	3 (2.3), 2 (1.2)	5 (1.7)
6/9	1 (0.8), 6 (3.7)	7 (2.4)	2 (1.6), 5 (3.1)	7 (2.4)	3 (2.3), 1 (0.6)	4 (1.4)
6/7.5	9 (7.0), 20 (12.3)	29 (10)	18 (14.1), 20 (12.3)	38 (13.1)	1 (0.8), 13 (8.0)	14 (4.8)
6/6	66 (51.6), 78 (47.9)	144 (49.5)	60 (46.9), 77 (47.2)	137 (47.1)	51 (39.8), 70 (42.9)	121 (41.6)
6/4	43 (33.6), 45 (27.6)	88 (30.2)	43 (33.6), 52 (31.9)	95 (32.6)	69 (53.9),75 (46.0)	144 (49.5)
Total	128 (100), 163 (100)	291(100)	128 (100), 163 (100)	291 (100)	128 (100), 163 (100)	291 (100)

n: number of the students.

University, which provides basic information on the prevalence of congenital colour blindness in the Faculty of Basic Medical Sciences of this institution. During the course of the research, both inherited and acquired colour blindness was discovered; though the number of students with normal colour vision predominates. However, this study is centred on congenital colour blindness which is caused by mutations in the gene responsible for colour vision on the X chromosome. As a result, inherited colour blindness is more prevalent in males compared to females. However, a female with two X chromosomes bearing the mutated genes will also be colour blind.

The prevalence of congenital colour vision defects as detected in this study is 1.7% (5 of 291 students) which was lower compared to figures in previous studies such as Ativie et al.[14] with 1.87% in Ugep, Cross River State and Oduntan et al.[15] with 2.5% in Lagos, Nigeria. Additionally, prevalences of 2.6% and 1.5% were reported in Southern and Northern parts of Nigeria respectively by Tabansi et al.[12] and Abah et al.[13] A comparison of the prevalences of colour blindness in other studies to the rate of 1.7% as seen in the present study showed that there is no significant difference among the Nigerian populace despite differences in habitats. Furthermore, referring to similar studies conducted in other African countries, Woldeamanuel and Geta[16] reported a congenital colour blindness prevalence of 4.2% in Southern Ethiopia. Also, Rahman et al.[10] and Pickford and Pickford[11] reported a prevalence of 2.2% and 3.57% in Libya and Zulu descent people respectively. This indicates that the prevalence of congenital colour blindness among African countries is comparative.

The prevalence of colour blindness in European Caucasians is about 8.4% in both men and women and between 4% and 6.5% in men of Chinese and Japanese ethnicity.[17] Furthermore, in Australia, there is a prevalence of 8% and 0.4% in males and females respectively.[18] Scandinavia also has a high prevalence of approximately 10%–11% in men. On the other hand, in sub-Saharan African nations, the prevalence of colour blindness is significantly lower compared to European Caucasians. Therefore, there is ample indication that the prevalence of colour blindness among black Africans is low compared to that of Caucasians (especially Scandinavians). The higher rate of colour blindness in Europeans and Asians is attributed to a large number of people with mixed race genes in their genetic history unlike that of Africans.

Table 4. Result of colour vision assessment

Colour Chart Score (numbers failed)	Colour blindness status	Male, n (%)	Female, n (%)	Total, n (%)
<8	Not colour blind	125 (97.7)	161 (98.8)	286 (98.3)
8 and above	Colour blind	3 (2.3)	2 (1.2)	5 (1.7)
Total		128 (100)	163 (100)	291 (100)

n: number of the students.

From our results, it is seen that only five students (1.7%) out of a population of 291 are colour blind. This verifies the general claim that colour blindness is a rare defect in Africa. The male respondents had a prevalence of 2.34% while females had a prevalence of 1.23%. This showed that the difference in occurrence of colour blindness between males and females is insignificant, which is in contrast to other studies conducted by Woldeamanuel and Geta[16], Ugalahi et al.[19] and Rahman et al.[10], where the prevalence of colour blindness is more in males than in females.

It was also discovered that of the five colour blind students, only two males were aware of having colour blindness. The third male who claimed not to have the defect actually had it. Likewise, the two females who were found to have colour blindness were not aware of their condition. This is in agreement to studies done by Mulusew and Yilikal[20] and Woldeamanuel and Geta[16], which reported that almost all of the study subjects were not aware of their colour vision status. Moreover, all of these five students who had colour blindness knew about this condition. Fifty-eight of the respondents, consisting of 19 males and 39 females, indicated that they have known vision defects such as myopia and hypermetropia, while the rest claim to have normal visual acuity.

Visual deficits among the medical students have been reported to be high and this negatively impacts students' learning and performance.[21] However, visual acuity assessment revealed that the majority of the respondents had normal or better than normal visual acuity. The visual acuity of the colour blind individuals was normal at a distance of 6 m except for one female colour blind individual who had myopia.

CONCLUSION

In some professions, proper colour recognition is essential and early detection of colour blindness is useful to avoid occupational hazards. This study shows that the prevalence of congenital colour blindness is 1.7% among medical students and it also raises awareness in those affected to enable them make any necessary adjustments. The prevalence of congenital colour blindness among medical school students can be said to be similar to other studies in our country. Colour blindness therefore can be considered a rare defect.

MAIN POINTS

Good vision is required to achieve optimum results in medical education and colour blindness could affect the learning process of a medical student when undertaking some tasks.

The prevalence of congenial colour blindness among medical students is 1.7% with a male to female ratio of approximately 2:1 respectively.

An early diagnosis of vision problems is valuable in career and vocational planning in order to help reduce the difficulties faced by people with vision defects.

ETHICS

Ethics Committee Approval: Nnamdi Azikiwe University Faculty of Basic Medical Science Ethics Committee (approval no: NAU/CHS/NC/FBMS/271, date: 15.10.2019).

Informed Consent: Prior to the investigation, a written informed consent form was obtained from the students after the procedure was explained to them.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Conception: N.D., E.N., Design: N.D., E.N., D.C.I., Supervision: N.D., D.C.I., Data Collection and/or Processing: N.D., D.C.I., Analysis and/or Interpretation: N.D., D.C.I., Literature Search: N.D., D.C.I., Writing: N.D., E.N., D.C.I., Critical Review: E.N., D.C.I.

DISCLOSURES

Conflict of Interest: No conflict of interest was declared by the authors.

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