Original Research Article

Pattern and prevalence of color vision disorders amongst secondary school students in Rivers State, Nigeria

ABSTRACT

Aims: To determine the prevalence and pattern of color vision disorders (CVD) amongst secondary school students in Rivers State.

Study design: A community based descriptive cross sectional study

Place and Duration of Study: Department of Ophthalmology, University of Port Harcourt Teaching Hospital from the 20th of January to the 30th of April 2014

Methodology: A community based descriptive cross sectional study where study subjects were selected using multi-stage random sampling technique with inclusion criteria of consenting students with visual acuity >6/24.Ethical clearance for test was obtained from institution . Socio-demographic data obtained using an interviewer administered questionnaire. A comprehensive ocular examination was done and color vision assessed using the Ishihara 24 plate 2009 edition and the Farnsworth Munsell D 15 test for those who failed the Ishihara test. The prevalence of color vision disorder was determined by those that failed the Ishihara test.

Data obtained was analyzed using SPSS version 21. Mean and standard deviations were determined for age. The age groups gender, other demographic distribution of the subjects amongst other were presented using frequency tables and charts

Statistical significance was put at $p \leq 0.05$.

Results: 1000 students were studied which consisted of four hundred and ninety five males (n=495; 49.4%) and five hundred and six females (n=506; 50.6%), with a male female ratio of 1:1.02. Mean age of subjects was 14.3±1.8 years with an age range of 9-20 years. The prevalence of color vision disorders was 2.8 % (p-value 0.000) and was higher in males (2.1%) than females (0.7%). (p-value 0.000). Deutan defects were the most predominant (1.8%) compared to protan defects (0.4%) and tritan defects (0.2%)

Conclusion: The study showed a prevalence of color vision disorders of 2.8% with male preponderance among secondary school students. Deutan color vision defects were most prevalent.

Keywords: color vision disorders, pattern, prevalence, Rivers State, secondary school

1. INTRODUCTION

Color vision disorder is defined as the inability to perceive and differentiate colors.

Color vision result from the selective absorption of light of different wavelengths by the cone outer segment visual pigments. Stimulation of the cones in different combinations enables the perception of color, with stimulation of all three cones ultimately resulting in perception of white. There have been few population studies on color vision deficiency as it is thought to be little or no interference with the activities of daily living of the color blind individual.[1]

Congenital Color Vision Disorder is most commonly a sex or X- linked genetic disorder with the defective gene located on the X chromosome within the Xq28 band,[2] while the blue pigment gene resides on the 7^{th} chromosome.[3] It could also be autosomal dominant especially with tritan disorders and rarely autosomal recessive (in achromatism).[4] The allelic frequencies for the color vision gene is said to be higher in males than females, with congenital CVD accounting for 8% in males and 0.5% in females.[5,6,7].

Color vision disorder has been studied in various ethnic groups and populations over time and is said to be a frequently inherited condition. The mode of inheritance of color vision disorders was first reported made by Dalton in 1798. [8]

There are also acquired causes of color vision deficiency, and these can be caused by damage to the optic nerve and brain, metabolic disorders such as diabetes mellitus, glaucoma, macular degeneration, chronic illnesses, exposure to industrial toxins, or drug overdose (digoxin, barbiturates, anti-tubercular drugs), or a result of side effects of drugs like sildenafil and chloroquine.[9]

Few studies have been carried out on vision screening in secondary schools in our environment and even fewer have been carried out solely to classify and grade color vision.

The previous study done in Rivers State was on primary school children, and did not classify the disorder, hence the need for this study on secondary school children at which stage definitive career

choices are likely to be made. Also, color vision screening is not routinely carried out in school age children.

2. METHODOLOGY

This was a community based descriptive cross sectional study where study subjects , public secondary school students from randomly selected schools who met the inclusion criteria were selected using multi-stage random sampling technique with inclusion criteria of consenting students with visual acuity >6/24. The sample population was approximated to 1000 students which were distributed across the 8 randomly selected schools.

Ethical approval was sought for and obtained from the Ethical Committee of University of Port Harcourt Teaching Hospital. Approval for the study was also obtained from the Local Inspector of Education within the LGA and the State Ministry of Education. Verbal approval was gotten from the principals of the selected schools. Written consent was gotten from the parents as well as verbal consent from the participating students.

Inclusion criteria

1. All secondary school students who consented to the study or whose consent was given by guardian or teacher
2. Students with visual acuity (VA) > 6/24

Exclusion criteria

1. Secondary school students with visual impairment (V.A <6/24) in the better eye.

Socio-demographic data was obtained using an interviewer administered questionnaire included age, sex, community and class.

A comprehensive ocular examination was done and color vision assessed using the Ishihara 24 plate 2009 edition and the Farnsworth Munsell D 15 test for those who failed the Ishihara test. The prevalence of color vision disorder was determined by those that failed the Ishihara test.

Data obtained was analyzed using SPSS version 17. Descriptive statistics such as means, frequencies and ratios were determined. Comparisons of associated variables were made with inferential statistics using p values.

Analysis was done using a Chi squared test and 2 tailed Fisher's exact test. Statistical significance was put at $p \leq 0.05$.

3. RESULTS AND DISCUSSION

One thousand secondary school pupils showing a 100% response rate were interviewed and examined for Color Vision Disorder during the study period

Table I: Probability proportion to size of population of the students in each School

Schools*	Student Population size	% population	sample population
1. GJSS EMOHUA	634	17.8	178
2. GSS EMOHUA	616	17.3	173
3. CJSS NDELE	441	12.4	124
4. CSS NDELE	363	10.2	102
5. CJSS OMOFO	360	10.1	101
6. Rundele CSS OMOFO	285	8.0	80
7. CJSS RUMUJI	399	11.2	112
8. CSS RUMUJI	463	13.0	130
Total	**3561**	**100.0**	**1000.0**

***CSS: community secondary school; CJSS: community junior secondary school**
***GSS: Government secondary school: GJSS: Government junior secondary school**

Table 2: Demographics of study population

N	Males	Female	M:F	Age range	Mean age
1000	495(49.5%)	506(50.6%)	1:1.02	9-20 years	14.3±1.8 years

There was no significant difference between the proportion of male (n=495; 49.4%) and female students (n=506; 50.6%) with X^2 *=0.144, df=1* and p-value *0.704.*
A prevalence of 2.8% for color vision disorder was gotten for this study, (p-value 0.000), following assessment with the Ishihara plates. This was similar to that gotten by Tabansi et al, [10] who had a prevalence of 2.6 % , Nwosu et al, [11] who also had a prevalence of 2.4% and Ugalahi et al,2.3% in Ibadan [12]. The slight differences noted may have been as a result of the differences in sample sizes. On the other hand, Ayanniyi et al, [13] got a lower prevalence (1.2%). This variation may be as a result of the larger sample size used by the latter and also by the fact that the population studied in Ilorin were primary school students and may have had difficulty in understanding the test instructions and carrying

them out.

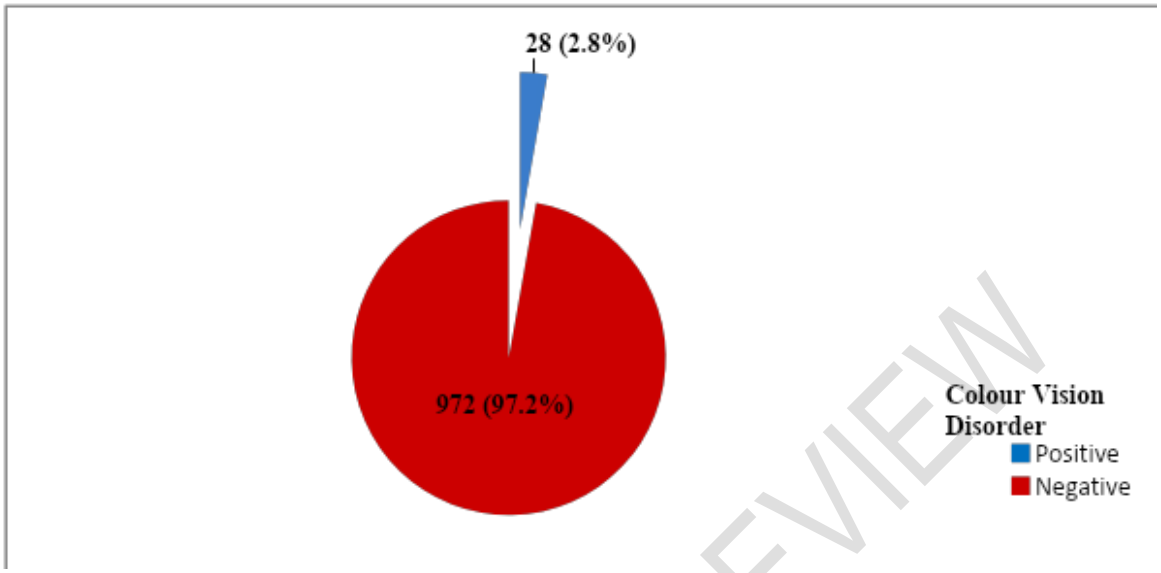

Figure 1: Prevalence of Color Vision Disorder among students

Differing from the index study, Mulusew et al, [14] in Ethiopia, reported the prevalence of congenital Color Vision Disorder to be 4.04% and Oriowo et al,[15] in Saudi Arabia recorded a prevalence of 5.85% while Horace et al,[16] in a study of CVD in American children, reported a prevalence of 6.2%.

These differences in the prevalence of Color Vision Disorder may be attributed to the fact that the distribution of CVD shows clear racial differences with white males having the highest prevalence of 7-10%, followed by the Orientals with 3-7% and Africans 2-3%.[17]

Delpero et al [18]in his study on aviation related epidemiology of CVD, also noted that there has been an over reliance on the worldwide prevalence of CVD of 8% and that this value applies to Euro Caucasians with the prevalence in Africans and Asians as low as 2%. In agreement with these studies, Mulusew et al, [14] described the overall prevalence of CVD in sub-Saharan Africa to be 2.63%.

On assessment of the 28 subjects who failed the Ishihara test with the Farnsworth Munsell D15 test, 24 subjects were classified into Deutan, Protan and Tritan patterns respectively while 4 were unclassified or had less than 2 crossings. Deutan pattern was the most common form of Color Vision Disorder seen in about two-third of the students with CVD (n=18; 64.3%) with a prevalence rate of 1.8%. This was statistically significant when compared with other forms of Color Vision Disorder (X^2= 16.42, df=2, p-value 0.0003). The prevalence rates for the other pattern of Color Vision Disorder includes Protan (0.4%), Tritan (0.2%) and those that were unclassified 0.4%.

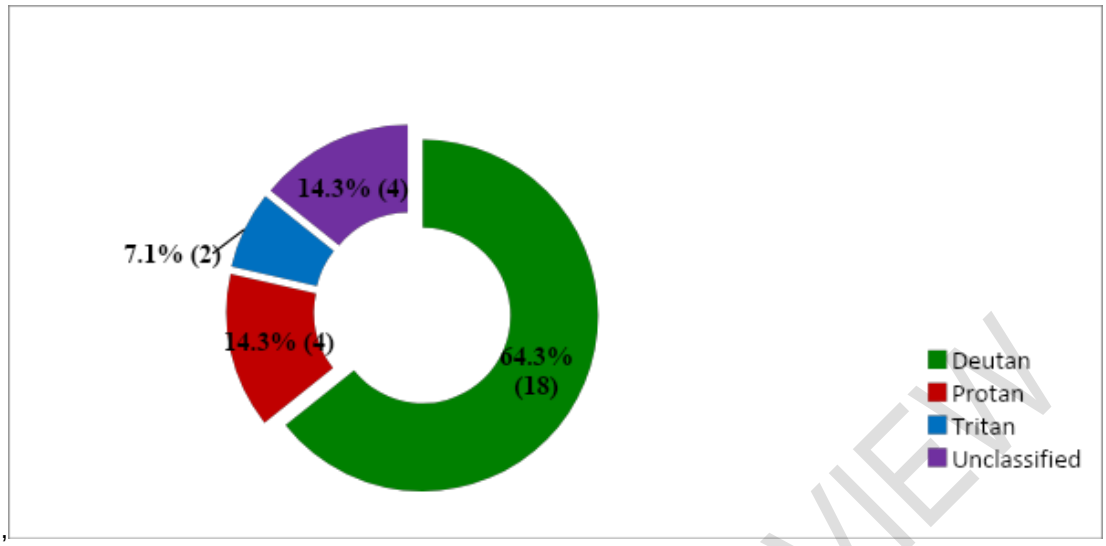

Figure 2: Pattern of Color Vision Disorder among students

Deutan was the most common pattern of color vision disorders when controlled for gender, with a prevalence rate of 1.4% among males and 0.4% among females as shown in Figure 3.
The prevalence for other color vision disorders in males are Protan (0.3%), Tritan (0.1%) and Unclassified (0.3%); while in females are 0.1% for Protan and Tritan respectively.

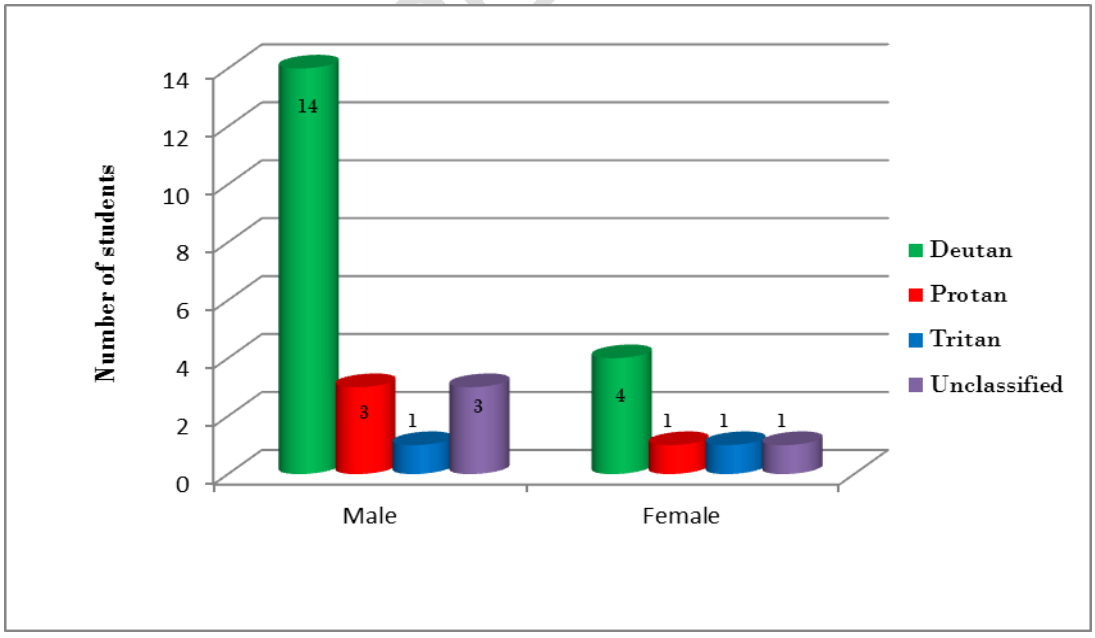

Figure 3: Pattern of color blindness in Males and Females

About half the students with CVD had either mild or near normal Color Vision Disorder.

There was a significant difference in the proportion of moderate and severe Color Vision Disorder between genders, with a higher proportion in males (X^2 = *4.212* df=1, p-value 0.032 and X^2 = 4.000, df=1, p-value =0.046 respectively).

Table 3: Severity of Color Blindness between Genders

Severity	**Gender**			
	Male n(%)	**Female n(%)**	**Total n(%)**	**p-value**
Near normal/Mild	9 (32.1)	5 (17.9)	14 (50.0)	0.091
Moderate	8 (28.6)	2 (7.1)	10 (35.7)	0.021
Severe	4 (14.3)	0 (0.0)	4 (14.3)	0.04
Total	**21 (75.0)**	**7 (25.0)**	**28 (100.0)**	

Table 4: Severity of Color Blindness in the different types of CVD

Severity	Deutan n(%)	Protan n(%)	Tritan n (%)	Unclassified n(%)	Total
Mild	7 (25.0)	2 (7.1)	1 (3.6)	4 (14.3)	14 (50.0)
Moderate	7 (25.0)	2 (7.2)	1 (3.5)	0 (0.0)	10 (35.7)
Severe	4 (14.3)	0 (0.0)	0 (0.0)	0 (0.0)	4 (14.3)
X^2	1.000	2.14	2.000	8.301	
p-value	0.606	0.341	0.312	0.016	
Total	**18 (64.3)**	**4 (14.3)**	**2 (7.1)**	**4 (14.3)**	**28 (100.0)**

The prevalence of CVD in males (2.1%) was found to be higher than that in females (0.7%) in the index study and this was statistically significant (p-value 0.000). This agrees with several studies carried out worldwide, [8, 19, 20, 21, 22, 23, 24, 25]' and may have also been influenced by the fact that the commonest inheritance pattern of CVD is said to be the X linked. [4] The prevalence in males in the index study was found to be lower than values gotten by William et al [21] in Lagos Nigeria and Tabansi et al, [10] in Port Harcourt. This may be explained by the fact that studies especially the former, had a larger sample size and had a higher proportion of color blind individuals.

The pattern of color vision disorders was assessed using the Farnsworth Munsell D15 test. Of the 28 subjects with color vision disorder, the Deutan pattern was found to be the commonest pattern (p-value 0.0003), with 18 students and a prevalence of 1.8%, Protan pattern had a prevalence of 0.4% while the tritan pattern had a prevalence of 0.2%.

This is in agreement with several studies, [5, 26, 27] carried out worldwide where the most prevalent pattern was of the Deutan type. Among the males, the Deutan pattern was also the commonest with a prevalence of 1.4% while it was 0.4% among the females.

The higher proportion of Deutan could also have been as a result of the fact that more Protans than Deutan with mild color deficiency pass the Farnsworth Munsell D 15 test. Following the assessment of pattern of CVD in this study with the Farnsworth Munsell D15 test, 4 (14.3%) color blind respondents as detected by the Ishihara test remained unclassified by the D 15 test, i.e. had less than 2 crossings and

as such could not be classified into a pattern. This is in agreement with the study by Birch et al, [28] who stated that people with mild color deficiency are intended to pass the D15 test with the test classifying individuals into either moderate or severe CVD, hence its use as an occupational screening test.

About half the respondents with CVD had near normal color vision or mild color vision disorder (50%), while 10% had moderate CVD and 4% had severe CVD. In all classes of severity, males had a higher preponderance. In the Deutan group, about 24% (24) where of the mild and moderate severity while 7% (7) had severe Deutan patterns.

This was similar to the study carried out by Singh et al, [29] where of the Deutans studied 26 had mild patterns while 8 had severe or strong patterns. It however differs slightly from the study carried in Punjab Indians where 20 were mild Deutans and 6 strong Deutans. [8] The difference in the frequencies may have been as a result of the difference in the number of color blind individuals. Also markedly differing was the study by Godar et al, [30] which had a frequency for strong Deutans as 0 and mild Deutans as 38. This high frequency may be attributed to the fact that it was a hospital based study and may not have been truly representative of the population.

4 **CONCLUSION**

From the findings of this research work, it can be concluded that the prevalence of CVD in secondary schools students in Rivers State was 2.8% with significantly higher prevalence amongst males as compared to females.

Most of the cases of CVD were mild in severity with the Deutan pattern being the most prevalent**.**

COMPETING INTERESTS

Authors have declared that no competing interests exist.”.

CONSENT (WHERE EVER APPLICABLE)

"All authors declare that ‘written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal."

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

“All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.”

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