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Prevalence of Congenital Color Vision Deficiency among Secondary School Students in Butajira Town, Ethiopia

Rabawit H Amare* and Samson B Tassew

Department of Ophthalmology, Addis Ababa University, Ethiopia

***Corresponding author:** Rabawit H Amare, Department of Ophthalmology, Medical Faculty, College of Health Sciences, Addis Ababa University, Ethiopia, Tel: +251911685439; Email: rabawit@gmail.com

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Abstract

Background: Color vision refers to our ability to perceive colors based on spectral variations in light absorbed by the photoreceptors. Color blindness or color vision deficiency is the inability or decreased ability to perceive color differences under normal lighting condition. This is predominantly caused by inherited photo pigment abnormalities in the retina resulting in a smaller number of visible spectral hues in both eyes. Red green color vision defects are common and caused by rearrangement and deletions of genes on the X-chromosome. Color blind persons, unaware of their disability, may choose certain professions, which may not be suitable for them, like traffic policeman, train driver or technician in color industries, which require proper color perception leading to lesser efficiency in work as well as may cause accidents.

Objectives: This study was conducted to find out the prevalence of color blindness among secondary school students in Butajira town, Gurage zone Ethiopia.

Methods: A cross sectional descriptive study was conducted from February 18, 2019 to March 8, 2019. A total of 779 (399 male & 380 female) students with age range of 14-25 years were selected using multistage sampling technique from three secondary schools. Participants were screened for color vision deficiency by using Ishihara's tests for color vision deficiency.

Results: Among the 779 students screened for color vision deficiency, 13 of them (1.7%) were diagnosed with color blindness out of which 12 were male and 1 was female. Deuteranomally was the most frequent color vision defect detected (11, 84.6%) and protanopia was the least detected color vision deficiency with 2 cases (15.4%). All participants with color vision deficiency were not aware of their color vision status.

Conclusion: Screening for color vision deficiency is potentially useful for adolescents in making carrier decisions. In our study participants were not aware of their color vision status or not informed about color vision deficiency and its impact in day to day life or future carrier performance. Therefore, we recommend early screening of children in order to help evaluate its effect in school activities and adolescence at time of entry to college in departments which require good color perception, training teachers on color vision deficiency screening to understand and help improve students' performance in school activities, creating awareness among the society about CVD and its effects in day to day and professional life and since prevalence of CVD varies in different ethnic groups further studies in other parts of the country may help to identify areas to focus on in the future.

Keywords: Ishihara's Tests; Photoreceptors; Fundoscopy, Blindness

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Introduction

Color vision refers to our ability to perceive colors based on spectral variations in light absorbed by the photoreceptors. Humans normally have trichromatic colour vision and possess three distinct classes of retinal cone photoreceptors i.e., L, M & S which are responsible for red, green and blue colors respectively [1]. Color blindness or color vision deficiency is the inability or decreased ability to perceive color differences under normal lighting condition. It is classified into congenital and acquired forms. The congenital color vision color defects (CCVD) are inherited as x linked recessive trait and most commonly red green defects. Acquired CVD is always associated with disease (systemic or ocular), toxicity or trauma. It is often tritan (blue-yellow) defect in nature [1-4].

The prevalence of CCVD varies among the different races, ethnic groups and sex with a higher preponderance in males [5]. Published studies showed that the prevalence is 8.3%, 2.8 % to 7.5% 3.0 % to 4.8% in European, Asian and African males respectively [6-10]. Previous school-based studies conducted in the different parts of Ethiopia reported varying results [9, 11-13]. The majority of school children with CCVD are unaware of their deficit thus accomplish poorly in class which involves colors and will affect their choice of career [11]. Unaware of their disability, may choose certain professions, which require proper color perception leading to lesser efficiency in work as well as may cause accidents. So, it is important to identify color vision defects in school children to provide proper counselling. The purpose of this study is to determine the prevalence and awareness of color blindness among secondary school students in Butajira town, Southern nations and nationalities SNNP, Ethiopia.

Subjects and Methods

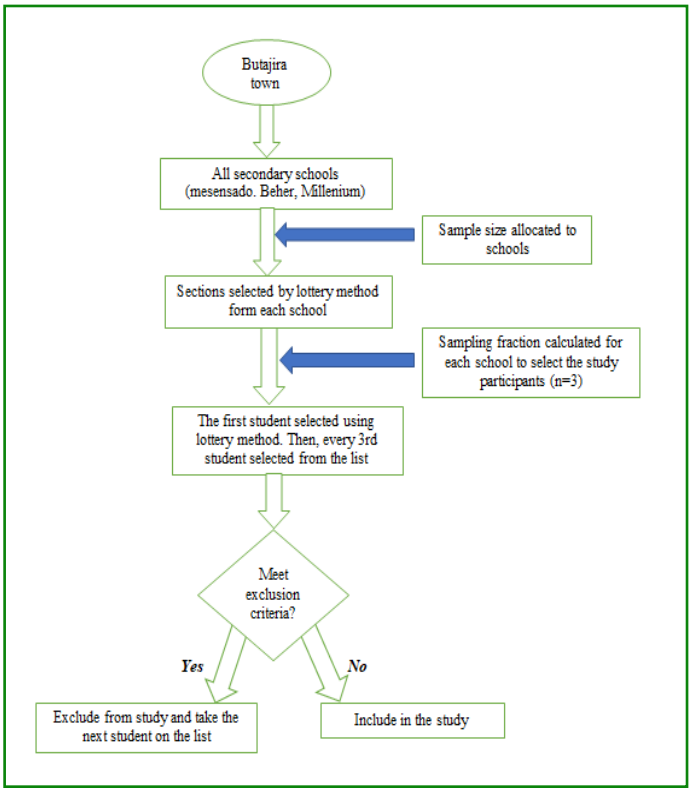
This is a descriptive cross-sectional study conducted between February 18, 2019 and March 8, 2019 at secondary schools in Butajira town Gurage zone Ethiopia. Butajira is a town and separate woreda in south-central Ethiopia. Located at the base of the Zebidar massif in the Gurage Zone of the SNNPR 131 km from A.A. the capital city of Ethiopia, this town has a latitude and longitude of 8°07′N 38°22′E and an elevation of 2131 meters above sea level. The town has 3 secondary schools. From a source population of all secondary school students in Butajira town a sample size of 779 is calculated by taking the prevalence of 4.2% obtained from previous study in Ethiopia [14], with 95% confidence interval, 2% margin of error, design effect of 2 and with the assumption of 90% response rate using the standard formula for the calculation of sample size.

$$n=\frac{Z^2\ P\ (1-P)}{d^2}$$

Where n: Sample sizes
Z: Z-Score for 95% confidence level (1.96)
P: Estimate of the proportion (0.042)
D: Degree of accuracy (0.02)

The study participants were selected through multistage sampling technique. All the three secondary schools and all grades in each school were included in the study. The students' lists were obtained from the school director office (home room teachers) and the total sample size was allocated proportionately to the schools (Mesenado, Millenium and Beher). Then a sampling fraction of 3 was calculated for each school. Next the total samples of each school were distributed to sections which were selected by lottery method. Finally, a systematic random sampling was employed to select study participants. The first sample student selected from the sampling fraction by lottery method and then the remaining possible sample students were selected depending on the fraction (every 3rd student taken). When the selected student fulfills at least one exclusion criterion or was absent on examination day, the next student on the list was selected. Students with any evidence of ocular pathology, trauma, previous ocular surgery, long term use of medication and students born to parents who are not from Ethiopia were excluded from the study in order to rule out acquired color vision deficiencies and to study its prevalence among Ethiopians.

Participant Selection Process



Data Collection Procedure

Demographic data including age, sex, grade, address, ethnicity, history of eye disorder, eye injury, use of medications, and awareness about their color vision defect was recorded in a prepared questionnaire. Ethnicity was categorized on the basis of self-reporting by the participants. Those who cannot or unwilling to specify are labelled as Ethiopians and who are born from parents of different ethnicity as mixed.

Snellen's E chart was used to test the visual acuity at 6 meters' distance with adequate day light illumination. All participants who had spectacles were tested wearing their spectacles. The color vision deficiency was determined using the 24-plate ishihara's test of color vision. Before administering the test, brief introduction was given. The color vision testing plates were held at 75 cm from the person and tilted at right angle to the line of vision. The test was done by the principal investigator in a class room with optimum natural day light. The time taken in each plate was not more than 3 second's delay. The first plate was presented first to check whether they follow the instruction correctly or not. The students were asked to read the numbers seen on the test plates 1 to 17. An assessment of the reading of plates 1 to 15 determines the normality or defectiveness of color vision. If 13 or more plates are read correctly, the color vision is regarded as normal. If only 9 or less than 9 plates are read correctly, the color vision was regarded as red green deficient. The plates 16 and 17 are used to differentiate protan and deutan types of color vision efficiency. (Ishihara's (2007)) All testing was done one eye at a time and those who had spectacles were tested wearing their spectacle. Unilateral CVD is suggestive of acquired causes.

Children who had deficient colour vision underwent detailed examination including fundoscopy after dilatation to search for secondary causes. Their choice of future carrier was asked. Then necessary counseling and guidance regarding the condition and its implication on future career was explained.

Data Analysis

Data was entered and cleaned using excel sheet and copied, coded and analyzed using SPSS version 23. Variables compared using the appropriate statistical tests. P values <0.05 is considered statistically significant.

Ethical Clearance

The department of ophthalmology research and publication committee, school of medicine, college of health science, Addis Ababa University approved the study protocol, which was conducted in accord with the tenets of the declaration of Helsinki. School principals and teachers were given a brief orientation on CVD including the benefit of screening. Verbal consent was obtained from the participants after brief orientation.

Result

A total of 779 school children participated in the study their ages ranging from 14 to 25 years with a mean (+ standard deviation) of 16.66+ 1.5 years. There were 399 (51.2%) males and 380 (48.81%) females. The majority were aged 14-19 years 731/779 (95.5%) and Christians 459/779 (60.1%). CCVD was found in 13 students giving a prevalence of (1.7 % 95% CI: 0.8 to 2.8). The prevalence of CCVD among males and females was 12/399 (3.0%) and 1/380 (0.26%) respectively (Table 1). There was a statistically significant association between sex and color blindness (p= 0.003) Table 2 showing the distribution of CVD among the different religions and ethnic groups is listed below.

Variables	Color vision status		Total	
	Normal	CVD	n	%
Age (years)				
14-19	731	13	744	95.50%
20-25	35	0	35	4.50%
Total	766	13	779	100%
Sex				
M	387	12	399	51.20%
F	379	1	380	48.80%
Total	766	13	779	100%
Religion				
Apostolic	4	0	4	0.50%
Jehovah	2	1	3	0.40%
Mixed	0	1	1	0.10%
Muslim	312	4	316	40.60%
Orthodox	307	4	311	39.90%
Protestant	141	3	144	18.50%
Total	766	13	779	100%
Ethnicity				
Amhara	27	1	28	3.60%
Ethiopian	45	2	47	6.00%
Gurage	559	8	567	72.80%
Hadiya	2	0	2	0.30%
Mixed	93	2	95	12.20%
Oromo	12	0	12	1.50%
Silti	22	0	22	2.80%
Tigray	6	0	6	0.80%
Total	766	13		100%
Awareness of color vision status	0	0	0	0

Table 1: Socio demographic data of study participants in Butajira, SNNP, Ethiopia, 2019.

Religion				Ethnicity			
	Frequency	Percentage			Frequency	Percentage	
		Among CVD	Within the Group			Among CVD	Within the group
Jehovah	1	7.70%	33.30%	Amhara	1	7.70%	3.60%
Mixed	1	7.70%	100%	Ethiopian	2	15.40%	4.30%
Muslim	4	30.80%	1.30%	Gurage	8	61.50%	1.40%
Orthodox	4	30.80%	1.30%	Mixed (Gurage + Amhara)	1	7.70%	3.10%
Protestant	3	23.10%	2.10%	Mixed (Kembata + Silti)	1	7.70%	100%
Total	13	100%			13	100%	

Table 2: Distribution of CVD among the different religions and ethnic groups in Butajira, SNNP, Ethiopia, 2019.

Out of the13 students with CCVD, 11 including the single female (1.41 %) were deutan and 1 (0.2 %) protan (Figure 1). No child was totally colour blind among the study population. Detailed examination of all students with CCVD did not reveal any ocular pathology. All of the CCVD students were unaware of their color vision status and two students considered being pilot, one astronomer and one electrician and others didn't choose future carrier (Table 3).

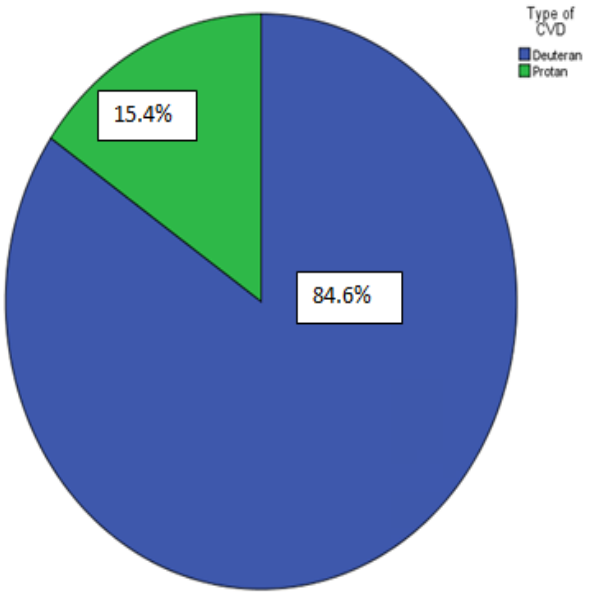


Figure 1: Frequency of types of CVD in Butajira, SNNP, Ethiopia, 2019.

	Color Vision Status		P-Value
	Normal	CVD	
Religion			
Jehovah	2	1(33.3%)	0.352
Mixed	0	1(100%)	
Muslin	312	4(1.3%)	
Orthodox	307	4(1.3%)	
Protestant	141	3(2.1%)	
Ethnicity			
Amhara	27	1(3.6%)	0.683
Ethiopian	45	2(4.3%)	
Gurage	559	8(1.4%)	
Mixed (Gurage+Amhara)	31	1(3.1%)	
Mixed (Kembata+Silti)	0	1(100%)	
Sex			
Female	379	1(0.3%)	0.003
Male	387	12(3.0%)	

Table 3: Association of CVD with religion, ethnicity and sex Butajira, SNNPR, Ethiopia, 2019.

Discussion

The current management of CCVD lies chiefly on appropriate counselling including career counselling [15]. Early identification of color vision defects in children is important for parents and teachers to make necessary adjustments during teaching to ensure effective learning of those with CVD and in making decisions about future career

choices. Those affected can be advised about occupational preclusions for safety reasons and quality of product which include police and defense forces, navigation, air traffic controllers in civil aviation, train drivers, artists (painters photographers, jewellers, tailors, fashion designers) [8,16]. Although the gold standard in detecting and classifying CCVD is the anomaloscope, unfortunately, its large size, cost, and importability make it a poor screening device. The Ishihara test is widely accepted as a screening tool for the assessment of color vision because it is highly sensitive and specific in the detection of red-green colour vision deficiency, easy to use and inexpensive [17].

The prevalence of CCVD detected in the present study was 1.7%, which is comparable to reports from eastern Ethiopia 1.60 %, Egypt 1.90% and South Africa 2.22% [9,18,19]. However, the result of this study is lower than the prevalence rate of 2.8% southern Ethiopia, 4.1% central Ethiopia and 4.2% northern Ethiopia [12-14]. This finding is also lower than reports from Saudi Arabia 3.4%, northern India 4.4% and Ireland, 5.3% [6,8,20]. Differences in prevalence could be attributed to differences in study population, geographical area, race and ethnicity [10,18].

The male prevalence of CVD found in our study is 3.0 % which is similar comparable with 3.0 % in Eastern Ethiopia, 2.80 % in Egypt and 3.18 % in Northern Ethiopia [9,14,18]. The prevalence rate of male color blindness as reported from different parts of the world are South Africa (4.20%), Saudi Arabia (5.85%), India (7.52 %), and Ireland (8.3%) [6,8,19,20]. In the present study the prevalence rate of female CCVD 0.26% was found to be similar with studies done in Eastern Ethiopia 0.2%, and lower than that of south Africa (0.60%), Nigeria (0.7%), Saudi Arabia (0.75%) and Egypt 0.9% [9,10,18-20]. The gender based differences in the frequency of CVD was found to be statistically significant with p value of 0.003 ($p < 0.05$), with a higher prevalence among male (3.00%) as compared to female (0.26%). Our finding is consistent with other studies [13,14,19] as CVD is a genetic disorder transmitted through the sex-linked recessive X chromosome [8,10].

Unlike studies done in central and south Ethiopia, the association between CCVD and religion was not found to be statistically significant (p value= 0.35). This can be explained partially by the community's perception on consanguineous marriages [12,13]. In this study, the most frequent type of color vision defect was deutan with deutan/protan ratio of 5.5 (11/2) (Figure 1). The high frequency of deutan defects was also observed in other studies [8-10]. Parallel to other studies done in the different parts of the country, total CCVD (achromatopsia) was not detected in this study [9,12,14].

In our study none of the CVD students were aware of their status which is also the case in other parts of the country [11,12]. More so four CCVD students chose professions which require proper perception of colors that indicates the need for CVD testing and informed career counselling. During the procedures, the students were briefed about CVD and the consequences it might have on career and day to day activities. Those with such defect were seriously advised to reconsider some other professions that may not require precise color perception and teachers were advised to take into consideration the status of the students with CVD as they may rely on utilizing colors while teaching and during examination.

The findings in our study implicate that even though the magnitude of CCVD is not as such significant, there seems to be a gap in the awareness of the condition and its consequence on school performance and career selection further affecting individuals' lives and that some children with CVD may be missed at level of primary school as they may not reach this level due to poor school performance affected by this condition.

Conclusion and Recommendation

In our study, prevalence of CVD was found to be less than most of the researches done in Ethiopia. Unfortunately, all students were not aware of their color vision status. Persons with CCVD should, therefore, ideally know about their condition so that they can be advised on appropriate career choices, especially during their early education years. Therefore, we recommend early screening of children in order to help them in school activities and adolescence at time of entry to college in departments that require precise color perception, training teachers on CVD screening to understand and help improve students' performance in school activities. This can be achieved by incorporating color vision screening alongside school screening programs. Creating awareness among the society about CVD and its effects in day to day and professional life also plays a vital role.

With this, we can prevent low school performance among students affected with CVD, psychological impact that comes with lesser efficiency at work and rejection from work places where the job needs sharp color perception and work related accidents associated with CVD. Finally, since prevalence of CVD varies in different ethnic groups further studies in other parts of the country may help to identify areas to focus on in the future.

Limitations

Unavailability of anomaloscope which is gold standard for the detection of CVD restricted us to do the test using Ishihara pseudoisochromatic plates which are also recommended for mass screening. Some participants were not willing

to disclose their ethnic background due to the current situation in the country. Thus it is difficult to conclude on the prevalence of CVD among the different ethnic groups in our study.

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