ORIGINAL ARTICLE

Screening for Congenital Color Vision Deficiency in Primary Children in Port Harcourt City; Teachers' knowledge and performance

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Abstract

Background: *One hundred and thirty teachers were studied to evaluate their knowledge of congenital Color Vision Deficiency (CVD), and their ability to perform the Ishihara color vision test, so as to determine if they can provide color vision screening services for their pupils.*

Methods: *The teachers were randomly selected from 13 schools in Port Harcourt City (PHC) and given a six hours training workshop on vision disorders in children and congenital color vision screening. They were given a self administered pre and post test questionnaires before and after training respectively. Subsequently, they screened 1,300 of their school pupils for congenital vision deficiency using the Ishihara color vision chart; and their results compared to that of the research team.*

Results: *Female teachers constituted 84.6% and males 15.4% of the study population. Seventy three teachers (53.8%) were from public schools while 46. 2% were from private schools.*

Prior to the training workshop, only 6.2% of teachers had heard of the Ishihara color vision chart and none of the teachers could identify or knew how to use the chart. However with training there was significant improvement in knowledge of CVD.

Comparison of the teachers' performance of color vision screening using the Ishihara chart to that of the research team showed a sensitivity of 67.6% with a specificity of 99.1%. The prevalence of congenital color vision deficiency in the 1,300 primary school screened was 2.6%, with males having a significantly higher prevalence than females.

Conclusion: *The study thus concludes that congenital color vision deficiency is prevalent amongst primary school children in Port Harcourt City, and with training, teachers can effectively perform color vision screening, and as such modify their teaching methods to accommodate the child with color vision deficiency.*

Keywords: *congenital color vision deficiency, school teachers, primary school children.*

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Introduction

Color Vision Deficiency (CVD) comprises a number of distinct disorders which collectively are relatively common. The most common of these is congenital color vision deficiency and is inherited as an X-linked recessive disorder which results in difficulty distinguishing colors in the red/green spectrum. Although it is a non progressive and untreatable disorder, universal population screening for early identification of affected children is a long standing practice in many developed countries, primarily so that advice can be provided early about occupations for which normal color vision is a requirement.

The prevalence of CVD in Britain is about 6.7% in males and 1.1% in females.[1] In a survey conducted among Sheffield schoolboys in England, Holroyd and Hall[2] found that 5.2% of boys had color vision deficiency. In contrast, Nwosu[3] found a prevalence of 2.4% in young adults in Anambra State, though the sampled population was relatively small (510 young adult) and the sex distribution of the color vision deficiency was also not stated in the report. The knowledge of one's color recognition status is important as some occupations preclude people with color vision deficiency because color recognition is crucial, and its deficiency is a serious handicap for such occupations, which include medicine, graphic arts, the creative arts, pilot training, military service, police, fire protection, electronics, chemistry, fashion designing and biology.[1,4-6]

The educational attainment of people with color vision deficiency may not be affected in the long term, but children with CVD are embarrassed and anxious when their teacher identifies objects by color or they are asked to use specific colors.[1] Many teachers are not

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aware of the effect of color vision deficiency on learning in young children. It is often taken for granted that all children see in color. Thus, books are printed in a variety of colors, with colorful graphics, colored maps, counting beads, and colored chalk, which may be more appealing to the normal color-perceiving person, but difficult for the color deficient student to see and to learn with.[7] If teachers are made aware of the potential problems of color blindness, steps could be taken to aid the students with this disorder, by slightly modifying their teaching methods; such as labeling with words or symbols, when a child needs color recognition, or increasing contrast by using white chalk on black board, and making black and white copies of colored textbooks.[7]

This study seeks to evaluate the knowledge, and ability to perform congenital CVD screening by primary school teachers following 6 hours of training, so as to determine if they can provide color vision screening services for their pupils.

Methodology

The study was conducted among primary school teachers and their pupils in Port Harcourt City (PHC). Port Harcourt City is one of the 23 Local Government Areas of Rivers State, located in the South-South geo-political area of Nigeria. There are 139 primary schools in PHC distributed within 3 primary school districts --Diobu district with 67 schools, Township district with 52 schools and Trans-Amadi district with 20 schools; giving a ratio of 6:5:2. This ratio was subsequently used to determine the number of schools (13) used in the study.

Stage I (selection of school teachers)

A multi-stage sampling technique was used to randomly select 130 teachers from 13 primary schools in PHC. A list of all schools obtained from the Rivers State Ministry of Education served as the framework from which the teachers were subsequently selected.

The schools were initially clustered into the three primary school districts in PHC. All schools within each district were then stratified into Public and Private schools. Then using the ratio of schools within each district i.e 6:5:2, 6 schools were chosen from Diobu district (3 public and 3 private) 5 schools from Township district (3 public and 2 private) and 2 schools from Trans-Amadi district (1 public and 1 private).

At each selected school, 10 teachers were randomly chosen from a list of all teaching staff in the school. (a total of 130 teachers were studied).

Stage 2 (recruitment of pupils)

From each selected teacher's Class Register, 10 pupils were randomly recruited for congenital CVD screening; giving a total of 1,300 pupils.

A self-administered questionnaire was initially given to the teachers to obtain information on bio-data, educational qualification, knowledge of CVD, Ishihara color vision chart and practice if any. They were also asked what action would be taken if they incidentally discovered a child with color recognition problem, and whom they would inform about this. After this pre-test questionnaire, they were given six hour training on vision disorders in children and congenital color vision screening using the Ishihara color vision chart. They were taught how to test for color vision using Ishihara's color vision charts, by asking the examinee to read off aloud, the number on each numeral plate of the 14 plates chart, at a distance of 75cm from the child within 3 seconds of observation, and graded the child as being color blind or normal, based on the scoring system provided in the chart. There were practical demonstrations with the instructors, and then they practiced with each other until full competence was attained. After the training, the teachers were given the same questionnaire as post-test. The training was done by the Ophthalmologist.

One week following training, each trained teacher performed Ishihara color vision screening on 10 of his/her school pupils randomly selected from the class register. After the teachers' screening, the research team re-screened all the pupils; for comparison of results.

The doctors' results were used as reference standard to calculate the sensitivity, specificity, positive and negative predictive value of the teachers' Ishihara color vision test using the following formulae:

$$\text{Sensitivity} = \frac{\text{True Positives (TP)}}{\text{True Positive (TP)} + \text{False Negatives (FN)}} \times 100\%$$

$$\text{Specificity} = \frac{\text{True Negatives (TN)}}{\text{True Negatives (TN)} + \text{False Positives (FP)}} \times 100\%$$

$$\text{Positive predictive value} = \frac{\text{True Positives (TP)}}{\text{True Positives (TP)} + \text{False Positives (FP)}} \times 100\%$$

$$\text{Negative Predictive Value} = \frac{\text{True Negatives (TN)}}{\text{True Negatives (TN)} + \text{False Ne gatives (FN)}} \times 100\%$$

The doctors' results were also used to calculate the prevalence of congenital CVD in the school children.

Analysis of data was by comparison of sub-set in simple proportions using chi-square test. Statistical significance at 95% confidence interval is $p < 0.05$.

Results

Evaluation of teachers' knowledge and performance of CVD

The responses to the pre-test questionnaire administered to the teachers are shown in table 1. The teachers generally had poor knowledge of vision problems and color vision deficiency in children before training. Only 56.9% of teachers were aware of school entry vision screening for pupils, and 8 (6.2%) had heard of the Ishihara color vision screening chart. Only 24 teachers (20.8%) agreed that color vision problems may cause poor academic performance. Also, 90 teachers (69.2%) responded that they would inform a parent if they thought a child had vision problems, but only 42 teachers (32.3%) would immediately change the child's sitting position to accommodate the child's deficiency.

Post test (table 2), 76% of teachers (100 teachers) manifested awareness of school entry vision screening (p= 0.002), 46.2% (60 teachers) now knew of the Ishihara vision screening charts (p= 0.000), 84.6% of teachers now knew of color blindness in children (p= 0.000), and more teacher (104) realized that color vision problems can cause poor academic performance.

As illustrated in table II, the result of the teachers post training questionnaire showed a significant increase in knowledge of CVD and color vision screening on most of the individual questions.

Table I: Pre-test on teachers' knowledge of CVD.

	YES	NO	No Response / I don't know
1. Awareness of school entry vision screening.	74	46	10
2. Compulsory school entry vision screening?	98	26	6
3. Knowledge of vision charts			
– Snellen's alphabet chart	66	10	54
– Snellen's 'E' chart	16	56	58
– Ishihara color vision chart	8	64	58
– others (specify)	None	None	None
4. Knowledge of color blindness	70	54	6
5. Knowledge of color recognition difficulties in some boys.	70	56	4
6. Color blindness causing poor academic performance.	100	24	6
7. what action may be taken on incidental finding of vision problem in a class pupil.			
–inform child's parent	90	0	40
–inform head teacher	38	0	92
–inform school nurse	12	0	118
–inform child	8	0	122
–change sitting arrangement	42	0	88
–do nothing	8	0	122

Table II: Post-test on teachers' knowledge of CVD.

	YES	No response NO		X^2	p- value
1. Awareness of school entry vision screening.	100	26	4	9.300	0.002
2. Compulsory school entry vision screening?	110	18	2	2.084	0.149
3. knowledge of vision charts					
– Snellen's alphabet chart	82	36	12	7.693	0.006
– Snellen's 'E' chart	60	54	16	15.26	0.000
– Ishihara color vision chart	60	58	12	30.72	0.000
4. knowledge of color blindness	110	16	4	29.50	0.000
5. knowledge of color recognition difficulties in some boys.	102	24	4	18.75	0.000
6. color blindness causing poor academic performance.	104	22	4	0.149	0.699
7. what action may be taken on incidental finding of vision problem in a class pupil.					
–inform child's parent	104	0	26	3.395	0.065
–inform head teacher	34	0	94	4.04	0.525
–inform school nurse	28	0	102	7.701	0.007
–inform child	16	0	114	2.808	0.094
–change sitting arrangement	46	0	84	0.190	0.663
–do nothing	10	0	120	0.206	0.650

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Table III: Proportion of teachers with color vision screening skill pre and post training

VISION SCREENING SKILLS	PRE TEST	POST TEST (%)
PASS	0 (0%)	110 (84.6%)
FAIL	130 (100%)	20 (15.4%)
TOTAL	130 (100%)	130 (100%)

Table IV: Comparison of teachers' and research team's Ishihara color vision test of school pupils.

		TEACHERS' ISHIHARA TEST		
		Color blind	*Normal*	*TOTAL Color vision*
RESEARCH TEAM'S ISHIHARA TEST	*Color blind*	23 (TP)	11 (FN)	34 (2.6%)
	Normal color vision	12 (FP)	1254 (TN)	1266(97.4%)
	TOTAL	35	1265	1300

Table V: Sensitivity, Specificity, Positive and Negative Predictive Value of teachers' color vision test.

PARAMETER	FORMULA USED	RESULT (%)
Sensitivity	$\frac{23}{23+11} \times 100\%$	67.6%
Specificity	$\frac{1254}{1254+12} \times 100\%$	99.1%
Positive Predictive Value	$\frac{23}{23+12} \times 100\%$	65.7%
Negative Predictive Value	$\frac{1254}{1254+11} \times 100\%$	99.1%

Table VI: Sex Specific Test status for Congenital Color Vision Deficiency in Primary School Children in PHC.

Ishihara Test	Females (%)	Males (%)	Total (%)
FAIL	5 (0.7)	29 (4.7)	34 (2.6)
PASS	675 (99.3)	591 (95.3)	1266 (97.4)
TOTAL	680 (100.0)	620 (100.0)	1300 (100.0)

Teachers' performance of color vision screening

The teachers' ability to perform color vision screening was assessed by asking them to identify and use the Ishihara color vision chart to perform a color vision screen on the investigator and research assistants.

As shown in table III, prior to training, none of the teachers could correctly identify the Ishihara color vision chart by name, or knew how to use it for screening. However, in the immediate period post training, 110 teachers (84.6%) correctly identified and used the Ishihara color vision chart for screening.

Comparison of teachers' Ishihara color vision test to that of the research team

Table IV compares the teachers' Ishihara color vision test result to that of the research team which was used as standard.

One thousand, two hundred and fifty four pupils detected to have normal color vision by the research team were correctly identified as having normal vision by the teachers (True NegativesTN). Twenty-three pupils detected as being color blind by the research team were correctly identified as being color blind by the teachers (True PositivesTP). Twelve pupils that have normal color vision by the research team screen were wrongly classified as being color blind by the teachers (False PositivesFP). Eleven pupils detected to be color blind by the research team were wrongly classified as having normal color vision by the teachers (False NegativesFN).

Using table IV as source, the sensitivity, specificity, positive and negative predictive value of the teachers Ishihara color vision test is shown in table V.

Prevalence of congenital color vision deficiency

The prevalence of congenital color vision deficiency in the primary school pupils re-screened by the research team was 2.6% (34 pupils out of 1,300); while the sex specific prevalence was 4.7% for males and 0.7% for females.

Discussion

This study reveals that the knowledge of color vision deficiency and practice color vision screening amongst school teachers in Port Harcourt City (PHC) was low prior to receiving a 6 hours skill training workshop. Specifically, Only 56.9% of teachers were aware of school entry vision screening for pupils, 8 teachers (6.2%) had heard of the Ishihara color vision chart, and only 24 teachers (20.8%) agreed that that color vision problems may cause poor academic performance. None of the 130 teachers recruited could correctly identify or utilize the Ishihara color vision chart. This finding is important because teachers' training curriculum ought to include health education which should address common health problems that may affect a child's academic performance. By such training, the teachers should be able to notice their pupils with health problems detrimental to their education and bring this to the attention of such pupil's parent for early intervention and remedy. That the teachers had poor knowledge of vision problems including CVD in children may suggest an inadequacy in content and/or time allocated to health education or a lack of emphasis on health issues in their training curriculum.

However, with training, there was a significant improvement in awareness of school entry vision screening ($p= 0.002$); more teachers now knew of color blindness ($p= 0.000$), and also more teachers realized that vision problems may lead to poor academic performance. The teachers also had improved knowledge about the use of Ishihara color vision chart. Although no comparative study can be found on teachers' performance specifically of color vision screening, the findings compares favorably to findings by Krumholtz[8] in New York, USA, who observed that there was a statistically significant increase in the ability of teachers to correctly identify vision problems (visual acuity related) from 39%, before being given a 40 minutes in-service lecture on vision problems, to 68% after the lecture. Similarly, Seethal and Karim[9]

evaluated a teacher vision awareness program in South Africa, and showed that teachers who attended a workshop on detection of vision problems correctly identified 66.1% of preschool children with vision problem by observation alone, compared to teachers who did not attend the workshop.[9]

Comparison of the teachers color vision deficiency test, using Ishihara color vision chart showed a sensitivity of 67.6%, with a high specificity of 99.1%, suggesting that the teachers can correctly detect up to two third of children with congenital color vision deficiency, and, identify almost all children with normal color vision correctly. The positive predictive value of the teachers' color vision test was 65.7%, indicating that two third of children identified as being color blind by the teachers, were indeed color blind. Also, the high negative predictive value of 99.1% achieved by the teachers indicated competence at identifying normal color vision in pupils.

Congenital color deficiency was found to have an overall prevalence of 2.6% in the school children screened by the research team. This finding in PHC compares favorably with the 2.4% found in Anambra State by Nwosu. It is however lower than the 6.1% and 5.2% seen in Britain, possibly due to ethnic and racial differences. However, the sex specific prevalence for CVD in males was found to be 4.7% while females had a prevalence of 0.7%. The difference, though significant (p=0.00008), is not surprising considering the X-linked recessive pattern of inheritance of the disorder. This sex specific prevalence is in keeping with studies in other parts of the world where prevalence ranges from 5% to 8% in males and 0.5% - 1.1% in females.[1,7] There is limited comparative data on prevalence of congenital color deficiency in Nigeria, but the study has revealed that Congenital CVD is indeed prevalent among male school children in Port Harcourt City. The import of this is that these affected children can be helped to find adaptive strategies more quickly, and take it into account while planning their career.

The school health program provides for routine vision screening of children on commencement of primary school, and at regular intervals subsequently. In places where it is practiced, up to 14% to 15% of defects can be detected, with early interventions provided.[10] The collapse of the school health program in the country may have contributed to the poor knowledge of congenital CVD and color vision screening amongst the teachers before training. Most developed countries practice routine vision screening for all pre-school and school children. In developing countries such as Nigeria, where there is relative scarcity of eye care specialists, teachers can be harnessed to provide the first level of school vision screening services including screening for congenital CVD. This would be a cost effective and feasible way to ensure it is done and sustained.

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