

RESEARCH ARTICLE

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# Colour Vision Deficiency: Prevalence and Associated Socio-demographic Characteristics among Commercial Motor-Vehicle Drivers in Benin City Metropolis, Edo State, Nigeria

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Submitted: 13<sup>th</sup> September 2024

Accepted: 11<sup>th</sup> March 2025

Published: 30<sup>th</sup> June 2025

[ID](#): Orcid ID

## Abstract

**Objectives:** Colour vision deficiency (CVD) is a suggested risk factor in road traffic injuries and deaths globally. This study aimed to determine the prevalence of CVD and associated socio-demographic characteristics (SDCs) among commercial motor vehicle drivers in Benin City, Edo State, Nigeria.

**Methods:** A cross-sectional study of 341 commercial motor-vehicle drivers aged  $\geq 20$  years in Benin City Metropolis using a purposive sampling technique. Socio-demographic data were collected using a self-administered questionnaire. Colour vision was assessed using Ishihara pseudochromatic colour plates. Data was analysed using IBM-SPSS version 29.0 and presented in tables and charts. Statistical significance was considered at  $P < 0.05$ .

**Results:** A total of 341 commercial drivers participated in the study. Males were 326 (95.6%), and females were 15 (4.4%). The prevalence of CVD was 9.6% (8.8% males and 0.8% females). Deuteranomaly was the major type of CVD. The age group 41-50 years, having a prevalence of 3.8% was the most affected. The prevalence of CVD increased with an increase in years of driving experience. The association between CVD and SDCs such as age groups, educational status, and years of driving experience, was not statistically significant ( $P > 0.05$ ).

**Conclusion:** The prevalence of CVD among drivers in this study was significant, and this could exacerbate road traffic accidents due to the inability to detect traffic signals and other road signs while driving. Routine colour vision assessment of drivers is recommended before issuance of driver's license and relicensing.

**Keywords:** Colour, vision, Deficiency, Drivers, Red-green, Accidents

## Plain English Summary

The inability of the eyes to identify and differentiate colours such as red, green and blue can increase the chances of road traffic accidents when driving. Colour vision tests done among commercial drivers in Benin City show a large number of drivers had problems distinguishing colours. This colour vision defect is worse among drivers that were advanced in age and also, those that had been driving for over

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ten years ago. It is advised that every driver should have their eyes tested for colour vision defects before they are given a driver's license and renew an expired driver's license.

## Background

Road traffic accidents (RTAs) are the world's top cause of mortality, and road traffic safety is a major public health concern (1, 2). When compared to high-income countries (HICs), the number of road traffic injuries and deaths in low- and middle-income nations (LMICs) is unquestionably larger (3). Research indicates that 60% of the world's motor vehicles are located in LMICs, and 93% of road traffic deaths occur there (1, 2). Driving requires a good ability to discriminate colours. On the other hand, research revealed that drivers who are colour-blind could find it challenging to read street signs, traffic signals, and brake lights (4). A range of disorders known as colour vision deficiencies (CVDs) are typified by a lack of ability to distinguish between colours. These deficiencies can be acquired or congenital. Males are affected by congenital forms of colour vision deficiencies more frequently than females (about 8% vs. 0.4%) (5). Several eye conditions, including cataracts, optic nerve disorders, and retinal diseases such as age-related macular degeneration, retinitis pigmentosa, diabetic retinopathy, and glaucoma, are frequently the source of acquired forms of colour vision deficiencies (6). In rarer cases, neurological injuries such as strokes or lesions occupying space might result in acquired colour vision deficiencies (6). The prevalence of colour vision abnormalities among commercial drivers ranges from 0% to 7%, with deuteranopia (a form of red-green colour blindness where the green-sensitive cone cells are absent, making it difficult to distinguish between red and green) being the most common abnormality (7, 8, 9, 10). Nevertheless, numerous earlier research has not found a connection between colour vision and traffic accidents (11, 12, 13). Studies on the prevalence of colour vision deficiency (CVD) in Nigeria suggest that it is more common in men than in women ranging from 2-6%, largely following global trends (14, 15, 16). Earlier studies have acknowledged the need for assessing colour vision during the periodic issuance of driver's licenses and relicensing (17, 18, 19). However, there is a paucity of findings regarding the prevalence of CVD among commercial drivers in Edo State. This study aimed to determine the prevalence and socio-demographic characteristics associated with CVD among commercial motor-vehicle drivers in Benin City, Edo State, Nigeria to ascertain its degree of burden and make recommendations for safe road driving.

## Materials and Methods

### *Study Design, Sampling Technique and Data Collection*

This was a descriptive cross-sectional study of colour vision among 341 healthy commercial motor-vehicle drivers aged 20 years and above in Benin City Metropolis, Edo State, Nigeria using a purposive sampling technique. Drivers that are registered with Edo state drivers' union as well as with road transport unions such as the National Union of Road Transport Workers (NURTW), Road Transport Employers Association of Nigeria (RTEAN), Cooperative Union of Road Transport Workers (CURTW) and those employed into Edo State Civil Services to drive the free BRT buses were recruited into the study. Data on socio-demographics such as age, sex, educational background, years of driving experience, number of hours driven daily e.t.c were collected using a self-administered questionnaire. Presenting visual acuity, colour vision test, as well as the integrity of the ocular structures were examined by qualified Optometrists using a trial lens set, retinoscope, Snellen charts, an ophthalmoscope and a pen torch. To acquaint the team of research assistants with the survey questionnaires and processes, a one-day training session was held.

### *Sample Size Determination*

The minimum sample size for this study was estimated using Cochran's formula (20),

$$n = \frac{Z^2 pq}{e^2}$$
 Where; n is the desired sample size, Z is the abscissa of the normal curve at a 95% confidence level (which is 1.96), e is the desired level of precision taken as 5%, p is the estimated proportion of an attribute that is present in the population which is taken as 27% i.e 0.27 [prevalence of commercial drivers with stereo-deficiency (21)], and q is 1-p.

$$n = \frac{(1.96)^2 \times 0.73 \times 0.27}{0.05^2} = 303$$
, and 10% attrition factor = 30. Therefore, minimum sample size = 333 Participants.

### *Assessment of Colour Vision*

Ishihara pseudochromatic colour plate 24th edition was used to assess colour vision. The Ishihara test is the most often used screening instrument for colour vision assessment in most nations (22). Based on Ishihara's instructions, the test was carried out in a room with optimal natural sunshine hours. The chart and the subjects under examination were 75 cm apart (23). The examination was done binocularly. Table 1 lists the numerals that can be found on plates 1–17. Every plate test was completed in a maximum of three seconds (21, 22, 23, 24).

**Table 1: Classification and Analysis of Colour Vision Plates**

Plate	Normal Colour Vision	Red-Green Deficiencies		Total Colour Blindness	
1	12		12	12	
2	8		3	X	
3	29		70	X	
4	5		2	X	
5	3		5	X	
6	15		17	X	
7	74		21	X	
8	6		X	X	
9	45		X	X	
10	5		X	X	
11	7		X	X	
12	16		X	X	
13	73		X	X	
14	23		5	X	
15	X		45	X	
		Protan		Deutan	
		Strong	Mild	Strong	Mild
16	26	6	(2) 6	2	2 (6)
17	42	2	(4) 2	4	4 (2)

The mark X indicates that the plate could not be read. The numerals in parenthesis show that they can be read but they are comparatively unclear. Normalcy of colour vision defects is determined by evaluating the readings of plates 1–15 (Table 1). A normal colour vision test result reads 13 or more plates normally. A person is said to have colour vision deficiency if they can read nine or fewer plates properly. But concerning plates 14 and 15, the only people whose readings are considered abnormal (Red-Green defect) are those who can read the digits 5 and 45 more easily than those on plates 10 and 9. Most people who were normal and those who were completely colour-blind were unable to read any numbers. In plates Numbers 16 and 17, the normal read as 26 (No. 16) and 42 (No. 17). In protanopia and strong protanomalopia, only 6 (No. 16) and 2 (No. 17) are read, and in the case of mild protanomalopia both numerals on each plate were read but the 6 (No. 16) and 2 (No. 17) are clearer than the other numerals. In deuteranopia and strong deuteranomalopia, only 2 (No. 16) and 4 (No. 17) were read, and in the case of mild deuteranomalopia both numerals on each plate were read but the 2 (No. 16) and 4 (No. 17) were clearer than the other numerals (23).

**Method of Data Analysis**

Data was entered in Microsoft Excel and analysed using IBM SPSS version 29.0 (SPSS, Chicago, IL, USA). The prevalence of CVD was presented in frequency tables and charts. Cross-tabulation and Chi-square tests were used to identify the sociodemographic characteristics linked to colour vision defects. Statistically significant was considered at P < 0.05, and all reported p-values were two-tailed.

**Results**

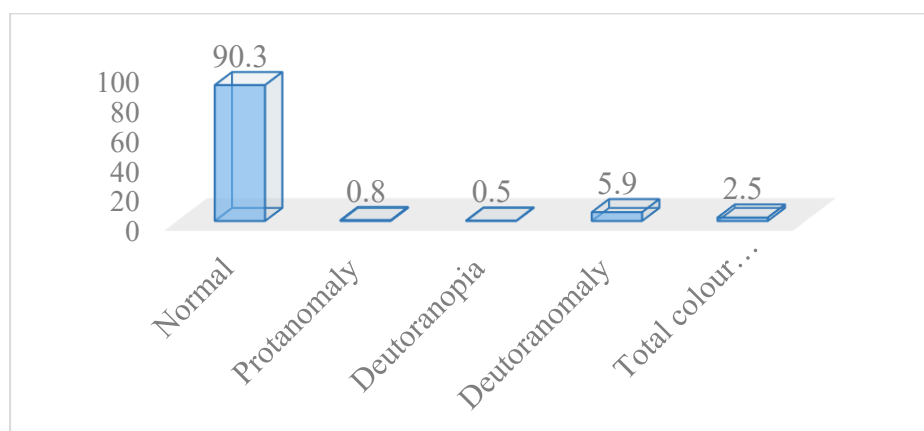
Over half of the respondents were Edos, followed by Deltans. The majority of the participants were male. The age groups 41-50 years and 51-60 years respectively made up the largest portion of the study population. The majority of the population were educated with over three-quarters having secondary and tertiary education. Over three-quarters of them were self-employed, and over half of the respondents had driving experience of over 10 years. Over two-thirds of the respondents drove above 5 hours daily, and had no road traffic accidents in the last year respectively. Meanwhile, about one-fifth reported 1-2 times road traffic accidents in the last year (Table 2).

**Table 2: Socio-Demographic Characteristics of Respondents**

Variables	Options	Frequency (N= 341)	Percentage (%)
Ethnic groups	Edos	202	59.2
	Igbos	33	9.7
	Deltans	47	13.8
	Yorubas	8	2.3
	Others	51	15.0
Gender	Male	326	95.6
	Female	15	4.4

Age Groups (years)	20-30	13	3.8
	31-40	41	12.0
	41-50	155	45.5
	51-60	82	24.0
	> 60	50	14.7
Educational Status	None	24	7.0
	Primary	53	15.5
	Secondary	136	39.9
	Tertiary	128	37.5
Employment Status	Self-employed	260	76.2
	Company employed	81	23.8
Years of Driving Experience	< 3 years	20	5.9
	3-5 years	33	9.7
	6-10 years	91	26.7
	> 10 years	197	57.8
Validity of driver's license	Currently valid	246	72.1
	Invalid	95	27.9
Hours driven per day	< 3 hrs	29	8.5
	3-5 hrs	60	17.6
	> 5 hrs	252	73.9
Number of road traffic accidents in the last one year	None	252	73.9
	1-2x	74	21.7
	3-4x	11	3.2
	> 4x	4	1.2

Over ninety per cent of the respondents had normal colour vision and 9.7% of them had CVD. Deuteranomaly was the major type of colour vision deficiency, followed by total colour blindness, and deuteranopia was the least occurring type of CVD among commercial drivers (Figure 1).



**Figure 1: Types of Colour Vision Deficiency among Commercial Drivers in Benin City**

In Table 3, 4.4% of Edos, 1.7% of Deltans, and 0.6% of Yorubas had CVD. Meanwhile, 8.8% of males and 0.8% of females had CVD. The age group 41-50 years with a prevalence of 3.8% is most affected compared to 0.6% among the age group 20-30 years. Findings show that 5% and 2.9% of respondents with secondary and tertiary education had CVD respectively compared to 1.8% in those with primary education. It was observed that CVD increases with an increase in years of driving experience from 0.6% in < 3

years to 2.9% in greater than 10 years of driving experience. CVD also increase with hours of driving daily from 0.6% in < 3 hours to 7% in > 5 hours driving daily. The results of this study show that the association between CVD and ethnicity, gender, age groups, educational status, employment status, years of driving experience, hours driven per day and number of road traffic accidents in the past year were not statistically significant ( $P > 0.05$ ).

**Table 3: Socio-demographic characteristics by CVD among Respondents**

Variables	Options	Colour Vision Deficiency		P-Value (P<0.05)	X <sup>2</sup>	DF
		Yes	No			
Ethnic groups	Edos	15	187	.350	4.313	4
	Igbos	4	29			
	Deltans	6	41			
	Yorubas	2	6			
	Others	6	45			
Gender	Male	30	296	.168	1.913	1
	Female	3	12			
Age Groups	20-30 years	2	11	.080	8.338	4
	31-40 years	3	38			
	41-50 years	13	142			
	51-60 years	5	77			
	> 60 years	10	40			
Educational Status	None	0	24	.210	4.484	3
	Primary	6	47			
	Secondary	17	119			
	Tertiary	10	118			
Employment Status	Self-employed	27	233	.523	.626	1
	Company employed	6	75			
Years of Driving Experience	< 3 years	2	18	.854	.796	3
	3-5 years	2	31			
	6-10 years	8	83			
	> 10 years	21	176			
Hours driven per day	< 3 hrs	2	27	.779	.535	2
	3-5 hrs	7	53			
	> 5 hrs	24	228			
Number of road traffic accidents in the last one year	None	22	230	.055	6.923	3
	1-2x	7	67			
	3-4x	2	9			
	> 4x	2	2			
Road traffic accidents	Yes	11	78	.319	.991	1
	No	22	230			

## Discussion

### *Prevalence of Colour Vision Deficiency*

The result of this study shows that the prevalence of CVD among the respondents was 9.7%. This result is similar to the result obtained from studies conducted in America which reported prevalence rates of CVD ranging from approximately 8% to 10% (25, 26). The value of 9.7% from this study was higher than the prevalence of 3.9% in India (21), 3% in Iran (19), 2.2% in South Africa (27) and 4.1% in Ethiopia (28, 29) as well as in Nigeria such as; 2.5% in Lagos (14), 2.3% in Ibadan (15), 2.6% in Port Harcourt (16) and 1.5% found in Zaria (30) as well as lower than the prevalence of 13.93 in Iran (31). Moreover, the value of 9.7% from this study was lower than the prevalence of 13.93% in Mashhad, Iran (31) and 21.3% in Jizan City, Saudi Arabia (32). This study also demonstrated that deuteranomaly with a prevalence of 5.9% was the major type of colour vision deficiency among the respondents. This

was followed by total colour blindness with a prevalence of 2.5%, which was similar to 2.6% reported in Egypt (33). In agreement, Simunovic reported that deuteranomaly affects approximately 5-6% of males and 0.4% of females globally (34), reflecting its X-linked recessive inheritance pattern. Similarly, deuteranomaly was reported to affect approximately 6% of males of Northern European descent in America (26). Contrarily, deuteranopia was the most prevalent CVD among Iranian drivers (19). This implies that most commercial drivers with CVD suffer from green colour discrimination which may pose significant difficulties in resolving daily activities with green colours such as clothing, road traffic and aviation signals (35). The differences in prevalence in this study compared to other studies especially in Nigeria may be due to variations in the geographical location of respondents (35), ethnicity/genetic make-up of respondents as well

as parents' consanguinity (marriage restriction between individuals who share a common ancestor) (33) due to geographical isolation or religious belief (26) and research design (15, 34, 36). While this current study was conducted among adult commercial drivers using Ishihara colour vision plates for assessment, most available literature on CVD assessment in Nigeria was conducted among school children using different methods including Richmond-HRR colour vision test plates (14, 15, 16, 30). This observed difference between the findings of the present study and other studies in Nigeria suggests the need for further investigation.

#### *Socio-demographic Characteristics Associated with Colour Vision Deficiency*

The prevalence of CVD was observed to be higher among the older respondents. The age group 41-50 years with a prevalence of 3.8% was most affected. This is similar to an earlier study which indicates that colour vision tends to decline with increasing age, primarily due to changes in the lens, retina, and optic nerve which can alter the perception of colours (37, 38). Findings also showed that CVD was higher among males (8.8%) than females (0.8%). This is in agreement with several studies that reported a higher prevalence of CVD among males than females due to X-linked recessive inheritance of CVDs (6, 14, 27, 28, 33, 35, 36, 39).s Earlier studies suggest that females have better colour discrimination abilities compared to males, possibly due to variations in cone photoreceptors, and genetic and environmental factors (40, 41). On educational status, 5% and 2.9% of respondents with secondary and tertiary education had CVD respectively. In agreement with the result of this study, earlier findings suggested that higher educational attainment and training in fields such as art, design, and visual sciences could be linked to improved colour discrimination abilities, reflecting cognitive development and visual acuity (42, 43). This might be explained by the colour-adaptive process of experiential learning due to brain plasticity to perform everyday tasks such as hobbies, plant/flower identification, ripeness of fruits and vegetables, and driving (44, 45, 46). The association between CVD and age groups, gender and educational status were not statistically significant in this study. Although, there was no significant correlation between CVD and report of RTAs, studies conducted by Atchison et al. (47) among normal and colour-deficient males, Cole among Australian drivers (12) and Tan et al. (39) in a comparative study in Southeast Asian countries found that drivers with CVD had slower response times to traffic signals,

predisposing to higher risk of accidents, particularly during extended driving hours.

#### *Strengths and limitations of the study*

Our study provides evidence-based data on the prevalence and associated socio-demographic characteristics of CVD among commercial drivers in Benin City metropolis to serve as a tool for formulating safe driving policy in Nigeria. Despite these strengths, the study is limited in that it employed self-appraisal of road traffic accidents which may not be reliable due to recall barriers. Although the Ishihara Pseudo-isochromatic plates test is the most often used screening instrument for colour vision assessment in most nations for congenital red-green deficiency (22), it lacks the Tritan (blue cones) screening plates and does not screen for yellow-blue CVD. Furthermore, the Ishihara test does have limitations in diagnosing the severity of CVD. Therefore, we recommend further studies covering more local government areas, and including other colour vision testing techniques such as Farnsworth-Munsell D15 colour vision arrangement tests and genetic testing (48, 49).

#### **Conclusion**

This study shows that the prevalence of CVD among commercial drivers in Benin City metropolis is higher than the prevalence found in other cities in Nigeria including Lagos, Ibadan, Portharcourt and Zaria. Our study indicates that CVD could exacerbate road traffic accidents as a result of the inability to detect traffic light signals and other road signs while driving. More so, deuteronomaly which is a type of red-green colour deficiency was the major type of colour vision deficiency among the study population. Although CVD did not significantly correlate with age, gender, driving experience and road traffic accidents, regular comprehensive eye examinations and colour vision status of commercial vehicle drivers before issuance of driving licences and relicensing is recommended to identify drivers with colour vision deficiency for safe driving.

#### **List of Abbreviations**

CURTW: Cooperative Union of Road Transport Workers  
 CVD: Colour Vision Deficiency  
 HICs: High-income countries  
 LMICs: Low- and middle-income nations  
 NURTW: National Union of Road Transport Workers  
 RTAs: Road traffic accidents  
 RTEAN: Road Transport Employers Association of Nigeria  
 SDCs: Socio-demographic Characteristics

SPSS: IBM Statistical Package for Social Science

### Declarations

#### *Ethics approval and consent to participate*

Ethical Approval for this study was obtained from the Ethical Committee of the Faculty of Life Sciences, University of Benin, Benin City, Edo State, Nigeria (FLSEC 2024/018). Permission was sought from the Director of Benin City Central Motor Park, Obakhavbaye as well as the chairman of Edo State Road Transport Workers and the National Union of Road Transport Workers. Informed consent was obtained from each participating driver. Participation in this study was entirely voluntary.

#### *Consent for Publication*

All the authors give consent for the publication of the work under the Creative Commons Attribution-Non-Commercial 4.0 license.

#### *Availability of Data*

The data sets used and analysed during the current study are available from the corresponding author on request.

#### *Competing interests*

The authors declare no competing interests.

#### *Funding*

There was no external support used for the conduct of this study.

#### *Authors' contributions*

Conceptualization: MJE, OAB; Data acquisition: MJE, NEU, EJA; Data analysis: MJE, OAB; Article writing: MJE, OEE; Manuscript review: MJE, FFA, OIN, AGN; Supervision: OAB, EJA, NEU; Final approval: MJE, OAB, OIN, OEE, FFA, EJA, AGN, NEU.

#### *Acknowledgement*

The authors acknowledge the study participants for their cooperation and patience. We also acknowledge the support of Dr. Mutali Musa and his team as well as the Benin City Central Motor Park staff for the success of the study.

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