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Visual functions and their association with road traffic accidents among vehicle drivers in Gauteng

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Background: South Africa has a high mortality rate because of road traffic accidents (RTAs) compared to other countries.

Aim: To determine the visual functions and their association with the occurrence of RTAs among vehicle drivers in the Gauteng province of South Africa.

Setting: Eight driver's license testing centres (DLTCs) in the Gauteng province.

Methods: A cross-sectional study involving a multi-stage random sampling approach was conducted. Data collected using the questionnaire included participants' demographic details. Ocular health examination included the measurement of visual acuity (VA), refractive errors, visual fields, colour vision, stereopsis, contrast and glare sensitivity.

Results: A total of 579 motor vehicle drivers were enrolled in this study. Drivers who reported daily alcohol consumption had a higher risk of being involved in RTAs (odds ratio [OR] = 1.8, 95% confidence interval [95%CI] = 1.09–2.99, P = 0.02). Visual acuity (OR = 1.43, 95%CI = 0.99–2.06, P = 0.05), refractive errors (P = 0.03, χ^2 = 61.57), abnormal contrast sensitivity (OR = 0.53, 95%CI = 0.31–0.93, P = 0.03) and deutan colour vision defects (P = 0.002, χ^2 = 31.42) were significantly associated with RTAs. Visual field defects (OR = 0.98, 95%CI = 0.97–1.00, P = 0.09), stereopsis anomaly (OR = 1.00, 95%CI = 0.99–1.00, P = 0.35) and abnormal glare sensitivity (OR = 1.00, 95%CI = 0.99–1.01, P = 0.32) were not significantly associated with the occurrence of RTAs.

Conclusion: These results suggest reviewing the visual requirements for obtaining a driver's license by incorporating colour vision and contrast sensitivity assessment.

Contribution: The study addresses a gap in the country's current vision testing standards for driving.

Keywords: visual functions; road traffic accident; visual acuity; refractive errors; visual fields; stereopsis; colour vision; contrast sensitivity; glare sensitivity.

Introduction

Good vision is an essential requirement for driving, and poor vision has been reported to be related to poor driving performance and the occurrence of road traffic accidents (RTAs).[1] Krug et al.[2] reported road traffic fatalities to affect an estimated 1.2 million people globally and 20m to 50m more people suffer bodily harm, with many incurring a disability. Road traffic accidents are a significant public health problem, occurring among people of working age (18–59 years) and are the leading cause of death and disability-adjusted life worldwide.[3] Although RTAs are a global epidemic, poor people in developing countries bear the highest burden of injuries and fatalities.[4] For example, in Africa, the annual death from road traffic injuries is 24.1 per 100 000 people compared to 10.3 per 100 000 people in European countries.[5] In South Africa, road traffic injuries remain significant.[6] The annual growth of RTA deaths per 100 000 has increased by 18% between the years 2000 and 2018 and 26.2% between 2020 and 2021.[6] These data reveal a substantial impact on both household income and the national economy in South Africa, with an estimated Gross Domestic Income (GDI) loss of 3.5% in 2017 and 3.98% in 2021, respectively.[7]

Safe driving behaviour requires a set of cognitive, sensory, motor and physical abilities.[8] Although approximately 95% of the sensory requirement for driving has been reported to be visual,[9] the association between visual functions and the occurrence of RTAs has yielded conflicting results. For example, several studies[10,11,12,13] found no association between visual functions and the occurrence of RTAs. Other recent investigations[14,15,16] have shown that visual functions such as visual acuity (VA), visual fields (VF), contrast sensitivity (CS), colour vision (CV), good stereopsis and the ability to adapt to various levels of illumination (glare sensitivity) are essential to a driver to avoid RTAs.

Visual acuity is a universal parameter assessed when obtaining a driver's license worldwide because of its significance in recognising road signs and highway markings and perceiving road hazards, including objects entering the roadway.[17] Oladehinde et al.[18] found poor VA to be strongly associated with RTAs among Nigerian commercial drivers. Visual field testing is a mandatory visual requirement for licensing in most countries.[14,15,16,17,18] Visual field loss is significant in predicting road safety and has been associated with deficits in driving performance.[19] Chakrabarty et al.[20] reported that CV defects lead to difficulty in recognising traffic signs and signals, as well as signals from other vehicles, which may lead to RTAs. Kusi et al.[14] also reported that protans were more likely to be involved in RTAs (χ^2 = 6.194, P = 0.034). However, Nwosu et al.[21] found no association between RTAs and CV defects. Stereopsis is the ability to appreciate depth and is important to accurately judge distances, overtake other cars and change lanes.[22] Defective depth perception may cause difficulty in judging distance, overtaking vehicles and changing lanes, thus posing a risk of motor vehicle accidents because of the inability to accurately perceive distances.[23] Contrast sensitivity is an essential visual function for driving and can help predict an individual's ability to detect and recognise an oncoming target or stationary object at a reasonable distance in a short time to make a decision.[24] Glare recovery is the ability to recover rapidly from exposure to glaring headlights and bright light that may present unpleasant discomfort and interfere with optimal vision and driving.[25]

Good visual functions are necessary for safe driving;[1] however, the current *South African Regulation 102 of the National Traffic Act (Act 96 of 1988)*[26] includes the assessment of VA and visual field parameters only. The purpose of this study was to investigate the relationship between VA, VF, CV, stereopsis, CS and glare and the occurrence of RTAs among drivers in the Gauteng province of South Africa.

Research methods and design

Study design and sampling

This was a descriptive cross-sectional quantitative study, which included active drivers across Gauteng province South Africa. Drivers were randomly recruited through a systematic random sampling technique of all active drivers across the eight randomly selected drivers' license testing centres (DTLCs) in the Gauteng province of South Africa. A list of all DLTCs in Gauteng was obtained from the Ministry of Transport. Eight randomly selected areas around Gauteng DLTCs were selected: Waterloo, Centurion, Xavier, Krugersdorp, Themba, Mabopane, Soweto and Silverton. Using the confidence level of 95%, 5% margin of error and a population proportion of 50%, the minimum sample size required for the study was 385 based on the Cochran's formula.

Data collection

The data were obtained from a structured questionnaire through face-to-face interviews and an ocular examination. The study was conducted from 01 February 2023 to 30 April 2023. The questionnaire consisted of socio-demographic information such as age, level of education and gender, driving-related characteristics including driving experience, knowledge of CV defects, stereopsis and glare sensitivity anomaly, alcohol consumption and history of RTAs (Appendix 1). The questionnaire was pilot-tested among 15 drivers who did not form part of the final study. All queries concerning the questionnaire during the pilot study were addressed, and the questionnaire was adjusted accordingly before the final study was carried out. The design of the questionnaire was based on a review of other related studies.[14,18,22] The questionnaire was tested for the internal validity of the items, and Cronbach's alpha coefficient score ranged from 0.70 to 0.74, indicating satisfactory consistency.[27] The interviews were conducted by the research assistant, who had prior experience in fieldwork and was trained for this study.

The ocular examination included measurement of VA, refractive errors, VF, CV, stereopsis, CS, glare sensitivity, intraocular pressure, and internal and external ocular examinations (Appendix 2). Visual acuity was measured monocularly with a LogMar chart at 4 M and 40 cm. The objective refraction was conducted on all drivers using a Huvitz Autorefractor (Huvitz Co., Ltd, Republic of Korea), and the measurements were refined subjectively to obtain the final spectacle prescription. Visual fields were measured using the Bernell Vision Disk (Mishawaka, INC), CV was assessed using the Hardy Rand Rittler (HRR) pseudo-isochromatic plates and stereoacuity was measured using the Randot Stereoacuity chart. Colour vision and stereopsis tests were performed using the participant's habitual prescription. Contrast sensitivity was assessed using a Mars Letter Contrast Sensitivity Test (The Mars Perception Corporation), and glare testing was performed using the photostress test. The I-Care tonometer (Finland) was used to measure intraocular pressure in all patients. External and internal eye examinations were assessed using panoptic direct ophthalmoscopy (Welch Allyn, Inc.). All drivers who had visual defects were referred for further examination.

Data analysis

Microsoft Excel and Stata version 18 were used for data entry and analysis, respectively. Independent samples *t*-tests and Chi-square (χ^2) tests were used to analyse associations between variables. The odds ratios and confidence intervals at a 95% confidence level were calculated using binary logic regression. Point estimate at 95% confidence interval and the *P*-value of 0.05 or less were considered statistically significant. Descriptive statistics and analysis of variance (ANOVA) results were also computed for variables.

Definitions

Normal VA was considered equal to or better than 0.2 LogMar (6/9) for heavy motor vehicle (HMV) and 0.3 LogMar (6/12) for light motor vehicle (LMV) drivers. Visual acuity of worse than 0.2 LogMar (6/9) or 0.3 LogMar (6/12) in either monocular or binocular was classified as poor vision for HMV and LMV drivers, respectively. The VA classification was based on the *Regulation 102 of the National Traffic Act (Act 96 of 1988)*.[26] This study defined myopia as a spherical power of –0.50, hyperopia as a spherical power of +1.00 or more and astigmatism as –0.50 cylinder or worse, in the better eye.[14] Temporal VF of 70° or more in each eye were considered normal and abnormal if less than 70°. For LMV, where one eye was less than 70°, the total minimum horizontal VF of 115° were considered normal and less than 115° were considered as abnormal. Log CS of higher than 1.48 was classified as normal and 1.48 or less was classified as abnormal.[28] Stereoacuity of less than 50 s of arc was considered normal, and scores greater than 50 s of arc were classified as abnormal.[29] Glare sensitivity of 50 s was considered normal and greater than 50 was considered abnormal.[30]

Ethical considerations

Ethical approval to conduct this study was obtained from the University of KwaZulu-Natal Biomedical Research Ethics (reference number: BREC/00000664/2019). A gatekeeper permission letter was obtained from the Ministry of Transport in Gauteng. All the drivers gave verbal consent after an explanation of the procedure involved in the study. The research adhered to the declaration of Helsinki involving human subjects.

Results

Demographic characteristics of drivers

A total of 579 drivers participated in the study and 430 (73%) were male participants. Their mean age was 41.5 ± 10.57 years (range: 22–81 years). A total of 353 drivers (61%) were in the age range of 36–59 years. A total of 290 (50%) drivers had middle and/or high school qualifications, 155 (27%) had secondary and/or technical qualifications and 132 (23%) had tertiary and/or post-secondary qualifications (Table 1).

History of road traffic accidents

A total of 162 (28%) drivers reported a history of RTAs, of which 137 (84.6%) were male participants and 25 (15.4%) were female participants. There was a statistically significant association between gender and history of involvement in RTAs ($\chi^2 = 12.491$, $P = 0.000$). Male participants had twice the odds (OR = 2.237, $P = 0.002$) of being involved in RTAs than female participants. The history of RTAs was more prevalent (70.4%) in the age group of 36–59 years. The mean age of drivers with a history of RTAs was 43.9 ± 9.2 years, while the 417 drivers who had no history of RTAs had a slightly lower mean age of 40.6 ± 10.9 years. Among the participants with a history of RTAs, 88.9% reported driving daily. There was a statistically significant association between the frequency of driving and the occurrence of RTAs ($\chi^2 = 22.827$, $P = 0.000$). The participants who drove daily had nearly four times (OR = 3.697, $P = 0.004$) the odds of being involved in RTAs relative to those who drove a few days a week.

Duration of driving and license renewal

The average age that drivers have been licenced was 14 ± 9.7 years, the longest drivers have been driving for 60 years while the least drivers have driven for less than 1 year. A total of 440 (76%) drivers had renewed their driving licence between 2019 and 2023 at the time of the study. A total of 445 (83.8%) drivers indicated having had a vision assessment before the renewal of their driver's licence (Table 1). A total of 162 (28%) drivers reported having tested their eyes more than 2 years ago and 128 (33%) had never had a comprehensive vision assessment (Table 1). There was a statistically significant association between the eye test for the renewal of a driving license and the occurrence of RTAs (odds ratio [OR] = 4.35, 95% confidence interval [95%CI] = 2.13–8.88, $P = 0.00$).

Driving licence, distance and frequency

A total of 443 (76.5%) drivers reported driving daily, 501 (86.5%) usually drove short distances (50 km – 200 km round trips) followed by 59 (10.2%) who drove middle distances (201 km – 500 km round trip). A total of 56 (9.7%) drivers reported having advanced driving skills, 459 (79.3%) had a license code of heavy motor vehicle (C1, C, EC1, EC) and 120 (20.7%) had an LMV license code (A1, A, B, EB).

Self-reported visual anomalies

Three (0.5%) drivers reported that they could not easily identify all the colours of the traffic lights. Of the 579 drivers who participated in the study, 42 (7.3%) reported difficulties judging distances when driving, of which 12 (28.6%) have been involved in RTAs. A total of 149 (25.7%) drivers reported difficulty driving at night because of glare from the oncoming traffic lights. Of this number, 37 (24.8%) had a history of being involved in RTAs.

Alcohol consumption and driving

Of the 74 (12.8%) drivers who reported consuming alcohol during normal working days, 29 (39.2%) drivers reported a history of RTAs. A binary logic regression showed that drivers who consume alcohol on a normal working day had higher odds of being involved in RTAs than drivers who did not (OR = 1.80, 95%CI = 1.09–2.99, $P = 0.023$). There was no statistically significant association between alcohol consumption and stereopsis ($\chi^2 = 1.596$, $P = 0.207$), CV defects ($\chi^2 = 0.442$, $P = 0.506$) or glare sensitivity ($\chi^2 = 2.468$, $P = 0.116$). Among drivers (162, 28%) with a history of RTAs, 119 (73.5%) drivers knew that continuous alcohol intake can affect one's ability to differentiate between the colours of the traffic, while 43 (26.5%) drivers did not have such knowledge. There was a significant association between the

TABLE 1: Sample characteristics.

Variable	Total sample		No history of road accidents (N = 417)		History of road accidents (N = 162)		P
	N	%	n	%	n	%	
Gender							
Male	430	74.0	293	70.0	137	85.0	-
Female	149	26.0	124	30.0	25	15.0	-
Gender and history of involvement in RTAs	-	-	-	-	-	-	0.00
Age (years)							
18–35	192	33.0	155	37.0	37	23.0	-
36–59	353	61.0	239	58.0	114	70.0	-
> 60	34	6.0	23	5.0	11	7.0	-
Level of education							
No formal education	0	0.0	0	0.0	0	0.0	-
Primary	2	0.4	1	0.2	1	0.6	-
Middle or JHS	290	50.0	220	53.0	70	43.0	-
Secondary or Technical	155	27.0	104	25.0	51	31.5	-
Post-secondary	132	23.0	92	22.0	40	25.0	-
Duration of driving experience (years)							
≤ 5	107	19.0	96	23.0	11	7.0	-
6–10	153	27.0	127	30.0	26	16.0	-
11–15	131	23.0	91	22.0	40	25.0	-
16–20	66	11.0	34	8.0	32	20.0	-
> 20	112	19.0	63	15.0	49	30.0	-
License renewal							
Never renewed	111	19.0	101	24.0	10	6.0	-
2009–2013	3	0.5	3	0.7	0	0.0	-
2014–2018	24	4.0	18	4.0	6	3.7	-
2019–2023	440	76.0	294	70.0	146	90.0	-
Driving license code							
Code A, A1, B, C (LMV)	120	21.0	82	20.0	38	23.0	-
Code C1, EB, EC, EC1 (HMV)	459	79.0	335	80.0	124	76.0	-
Eye examination before license renewal							
No	94	16.0	85	20.0	9	6.0	-
Yes	485	84.0	332	80.0	153	94.0	-
Eye examination before license renewal and RTAs	-	-	-	-	-	-	0.00
Last comprehensive eye examination (years)							
< 1	98	17.0	72	17.0	26	16.0	-
1–2	191	33.0	133	32.0	58	36.0	-
> 2	162	28.0	117	28.0	45	28.0	-
Never	128	22.1	90	22.0	33	20.0	-
Ability to identify the colours of the traffic lights							
No	3	0.5	2	0.5	1	1.0	-
Yes	576	99.5	415	99.0	161	99.0	-
Level of education and identification of traffic light colours	-	-	-	-	-	-	0.45
Difficulty judging distance when driving							
No	537	93.0	387	93.0	150	93.0	-
Yes	42	7.0	30	7.0	12	7.4	-
Difficulty driving at night because of glare from on-coming traffic lights							
No	430	74.0	305	73.0	125	77.0	-
Yes	149	26.0	112	27.0	37	23.0	-
Alcohol consumption on a normal working day							
No	505	88.0	372	89.0	133	82.0	-
Yes	74	13.0	45	11.0	29	18.0	-
Alcohol consumption and occurrence of RTAs	-	-	-	-	-	-	0.02
Alcohol consumption and colour vision defect	-	-	-	-	-	-	0.51
Alcohol consumption and stereopsis anomaly	-	-	-	-	-	-	0.21
Alcohol consumption and glare sensitivity	-	-	-	-	-	-	0.12

JHS, Junior High School; LMV, light motor vehicle; HMV, heavy motor vehicle; RTAs, road traffic accidents.

knowledge of continuous alcohol intake's effect on the ability to differentiate between colours of the traffic light and involvement in RTAs (χ^2 = 5.266, P = 0.022). The participants who had no knowledge that continuous alcohol intake can affect the ability to differentiate between colours of traffic lights had almost twice the odds (OR = 1.842, P = 0.009) of being involved in RTAs than those who had such knowledge.

Drivers' vision

Spectacle use

One hundred and forty-five (25%) drivers reported a history of spectacle use. Forty-three (29.7%) out of 145 drivers using spectacles reported a history of RTAs. Of this number, 18 (41.9%) wore multifocal, 15 (34.9%) were distance correction spectacles and 10 (23.3%) were near vision correction. There was no statistical association between spectacle wear and the occurrence of RTAs (χ^2 = 0. 2696, *P* = 0.604).

Visual acuity of drivers

A total of 379 (79.3%) drivers with HMV license codes had a binocular VA of 0.2 LogMar (6/9 Snellen acuity) or better. Sixty-nine (15%) drivers presented with VA worse than 0.2 LogMar (6/9 Snellen acuity) (Table 2a). Among the drivers with reduced VA, 32 (46.4%) had reduced binocular acuity, and 22 (31.9%) and 15 (21.7%) presented with reduced monocular acuity in the right and left eyes, respectively. A total of 21 (30.4%) of these drivers indicated a history of RTAs.

A total of 120 (20.7%) participants had LMV license codes. A total of 115 (95.8%) of the participants in this category had a VA of 0.3 LogMar (6/12 Snellen acuity) or better in the worse (*n* = 7, 6.1%) or better eye (*n* = 11, 9.6%). Five (4.2%) participants had reduced binocular VA of worse than 0.3 LogMar (6/12). Three (60%) out of five participants with reduced binocular acuity had been involved in a road accident. However, there was a statistically significant association between VA and involvement in RTAs (OR = 1.427, 95%CI = 0.988–2.061, *P* = 0.04). Twenty-three out of the 120 drivers in this category did not meet the current VA requirement for driving.

Refractive conditions

A total of 486 (83.9%) drivers had refractive errors. Of the 486 drivers with refractive error, 235(48.4%) had astigmatism, 43 (8.8%) had myopia, 17 (3.5%) had hyperopia and 49 (10.1%) had presbyopia. There was a statistically significant association between poor vision because of refractive error and the occurrence of RTAs (χ^2 = 61.5667, *P* = 0.033). In addition, 91 (18.7%) drivers had myopic astigmatism and 51 (10.1%) drivers had hyperopic astigmatism. Myopia (OR = 1.767, *P* = 0.002), hyperopia (OR = 3.360, *P* = 0.000), myopic astigmatism (OR = 1.767, *P* = 0.007) and hyperopic astigmatism (OR = 3.658, *P* = 0.000) were statistically significantly associated with RTAs occurrence.

Visual fields

A total of 556 (96%) participants presented with VF of 70°-temporal in each eye. Twenty-three (4%) drivers had reduced VF of less than 70° temporal in the worse (10, 43.5%), better (*n* = 7, 30.4%) or both eyes (6, 26.1%). Among drivers with visual field defects, 16 (69.6%) were heavy and 7 (30.4%) were LMV licensed drivers. Eight (34.8%) participants reported a history of RTAs, and 7 (87.5%) of whom were heavy motor vehicle licensed drivers. There was no statistically significant association between reduced VF and the occurrence of RTAs (OR = 0.983, 95%CI = 0.965–1.003, *P* = 0.089).

Colour vision

A total of 514 (88.8%) drivers had normal CV and 65 (11.2%) had CV defects. Of those with CV defects, 50 (76.9%) had binocular defects and 15 had monocular defects. There were 35 (53.8%) deutans, 14 (21.5%) protans, four (6.2%) tritans, two (3.1%) tetartans and 10 (15.4%) had no colour perception (Table 2a and Table 2b). Twenty-three (35.4%) drivers with CV defects reported a history of RTAs, of which most (*n* = 17, 73.9%) had binocular defects. Drivers with deutan CV defects were more likely to be involved in RTAs compared to protans and tritans (χ^2 = 31.42, *P* = 0.002). A total of 397 (68.6%) were aware that some individuals cannot differentiate colours and 461 (79.6%) indicated that continuous alcohol consumption could impact their colour perception (Table 2a and Table 2b).

Stereopsis

A total of 82 (14.2%) drivers had abnormal stereopsis, 26 (31.7%) of which reported having been involved in RTAs. However, there was no statistically significant association between reduced stereopsis and RTAs (OR = 1.001, 95%CI = 0.999–1.003, *P* = 0.347). A total of 463 (80%) were aware that individuals may have difficulty judging distance correctly when driving. A total of 548 (94.6%) indicated that alcohol consumption could impact their ability to judge distances while driving and 31 (5.4%) were not aware.

Contrast and glare sensitivity

Eighty-one (14%) drivers had abnormal CS, of whom 26 (32%) have been involved in RTAs. There was a statistically significant association between CS and RTAs (OR = 0.531, 95%CI = 0.305–0.925, *P* = 0.025). Twenty-eight (32.2%) of the 87 (15%) drivers who had abnormal glare sensitivity were involved in RTAs. A total of 149 (25.7%) drivers reported having difficulty driving at night because of glare from on-coming traffic lights, and 37 (24.8%) of them had been involved in RTAs. Five hundred and forty-two (93.6%) were aware that individuals have difficulty driving at night because of oncoming traffic lights. Similarly, 549 (94.8%) drivers indicated that alcohol could affect their ability to see oncoming traffic lights at night. There was a statistically significant association between glare sensitivity and CS (OR = 0. 932, 95%CI = 0.910–0.955, *P* = 0.000).

Ocular health

A total of 150 drivers (25.9%) and 91 drivers (15.7%) had pingueculas and pterygia, respectively (Figure 1).

Fifty-eight (10%) drivers had cataracts, of which 17 (29.3%) drivers reported having been involved in RTAs. Forty-six (79.3%) of the participants with cataracts also had reduced stereopsis, 28 (48.3%) participants had reduced CS, 22 (37.9%) participants had CV defects and 17 (29.3%) participants

TABLE 2a: Visual characteristics and their associations with road traffic accidents.

Variable	Total sample		No history of road accidents (*N* = 417)		History of road accidents (*N* = 162)		*P*
	n	%	*n*	%	*n*	%	
Static visual acuity							
License code: C1, C, EC1, EC	459	79.0	-	-	-	-	-
≥ 0.2 LogMar	390	85.0	287	69.0	103	64.0	-
< 0.2 LogMar	69	15.0	48	11.5	21	13.0	-
License code: A1, A, B, EB	120	21.0	-	-	-	-	-
≥ 0.3 LogMar							
Binocular (OU)	97	81.0	69	17.0	28	17.0	-
Monocular (OD)	7	6.0	4	1.0	3	2.0	-
Monocular (OS)	11	9.0	7	2.0	4	2.0	-
< 0.3 LogMar (OU)	5	4.0	2	0.5	3	2.0	-
Visual acuity and the occurrence of road accident	-	-	-	-	-	-	0.058
Refractive error							
No	93	16.0	75	18.0	17	10.0	-
Yes	486	84.0	-	-	-	-	
Myopia	43	9.0	31	7.0	12	7.0	-
Hyperopia	17	3.0	13	3.0	4	2.0	-
Astigmatism	235	48.0	162	39.0	73	45.0	-
Myopic astigmatism	91	19.0	67	16.0	24	15.0	-
Hyperopic Astigmatism	51	10.0	34	8.0	15	9.0	-
Presbyopia	49	10.0	30	7.0	19	12.0	-
Refractive error and occurrence of RTAs	-	-	-	-	-	-	0.033
Visual fields defects							
No	556	96.0	397	95.0	159	82.0	-
Yes	23	4.0	15	4.0	8	5.0	-
Visual fields and the occurrence of road accident	-	-	-	-	-	-	0.089
Stereopsis							
Normal	497	86.0	361	87.0	136)	84.0	-
Abnormal	82	14.0	56	13.0	26	16.0	-
Stereopsis and the occurrence of RTAs	-	-	-	-	-	-	0.347
Knowledge of stereopsis anomaly							
No	116	20.0	89	21.0	27	17.0	-
Yes	463	80.0	328	79.0	135	83.0	-
Effect of alcohol on stereopsis							
No	31	5.0	25	6.0	6	4.0	-
Yes	548	95.0	392	94.0	156	96.0	-
Glare sensitivity							
Normal	430	74.0	305	73.0	125	77.0	-
Abnormal	149	26.0	112	27.0	37	23.0	-
Glare sensitivity and the occurrence of RTAs	-	-	-	-	-	-	0.327
Knowledge of glare sensitivity anomaly							
No	37	4.0	29	7.0	8	5.0	-
Yes	542	94.0	388	93.0	154	95.0	-
Effect of alcohol on glare sensitivity							
No	30	5.0	21	5.0	9	6.0	-
Yes	549	95.0	396	95.0	153	94.0	-
Contrast sensitivity							
Normal	498	86.0	358	62.0	140	86.0	-
Abnormal	81	14.0	45	11.0	26	16.0	-
Contrast sensitivity and the occurrence of RTAs	-	-	-	-	-	-	0.025
Effects of glare on contrast sensitivity	-	-	-	-	-	-	0.00
Colour vision							
Normal	514	89.0	375	90.0	139	86.0	-
Abnormal	65	11.0	-	-	-	-	-
Monocular defect (OD)	7	11.0	3	1.0	4	2.0	-
Monocular defect (OS)	8	12.0	6	1.0	2	1.0	-
Binocular defect (OU)	50	77.0	33	8.0	17	10.0	-
Type of colour vision defect†							
Protan	14	21.0	11	3.0	3	2.0	-
Deutan	35	54.0	25	6.0	10	6.0	-
Tritan	4	6.0	1	0.2	3	2.0	-
Tetartan	2	3.0	2	0.5	0	0.0	-
No colour perception	10	15.0	3	1.0	7	4.0	-

TABLE 2a continues on the next page →

TABLE 2a (Continues...): Visual characteristics and their associations with road traffic accidents.

Variable	Total sample		No history of road accidents (N = 417)		History of road accidents (N = 162)		P
	n	%	n	%	n	%	
Knowledge of colour vision defect							
No	182	31.0	131	31.0	51	31.5	-
Yes	397	69.0	286	69.0	111	68.0	-
Effect of alcohol on colour vision							
No	118	20.0	75	18.0	43	26.0	-
Yes	461	80.0	342	82.0	119	73.0	-

RTAs, road traffic accidents.
†, please see Table 2b for further information relating to the extent of colour vision defects.

TABLE 2b: Visual characteristics and their associations with road traffic accidents: The extent of colour vision defects.

Type of defect	Mild		Medium		Strong		P
	n	%	n	%	n	%	
Protan	9	64.0	3	21.0	2	14.0	-
Deutan	30	86.0	2	6.0	3	7.0	-
Tritan	1	25.0	1	25.0	2	50.0	
Tetartan	-	-	-	-	2	100.0	-
Colour vision defects and occurrence of RTAs	-	-	-	-	-	-	0.002

RTAs, road traffic accidents.

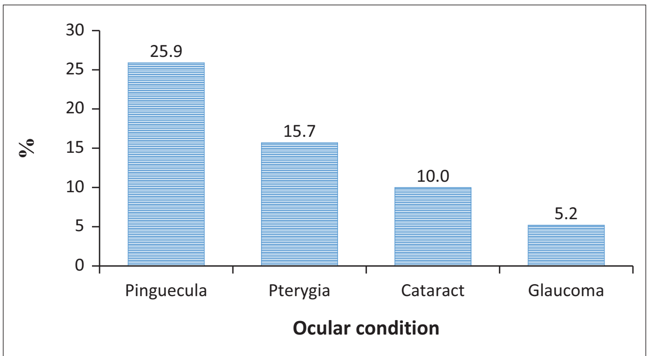

FIGURE 1: Percentages of ocular conditions among drivers.

reduced glare sensitivity. There was a statistically significant association between cataract and stereopsis, CV defects, contrast and glare sensitivity (all P < 0.005). Thirty (5.2%) drivers had glaucoma, of which 10 (33.3%) drivers reported being involved in RTAs. Four (13.3%) participants with glaucoma had visual field defects and 50% (n = 2) of these have been involved in RTAs. Eleven (36.7%) drivers with glaucoma had reduced CS, and six (20%) drivers had reduced glare sensitivity, stereopsis and CV defects. There was a statistically significant association between glaucoma and stereopsis (χ^2 = 10.35, P = 0.006). However, there was no statistically significant association between glaucoma and CV defects, contrast and glare sensitivity (all P > 0.05).

Discussion

This study sets out to investigate the association between visual functions and the occurrence of road accidents among drivers in the Gauteng province of South Africa. The findings of the study show that alcohol consumption, refractive errors, poor VA, abnormal CS and deutan CV defects were significantly associated with RTAs.

A total of 162 (28%) drivers reported having tested their eyes more than 2 years ago and 128 (22%) drivers had never had a comprehensive vision assessment (Table 1). Nearly one-third (28%) of the drivers had their eyes tested more than 2 years ago and 128 (22%) drivers had never had an eye examination before the issuance of a driving license. This shows that eye tests are not routinely carried out contrary to the current National Road Traffic Regulations that require a certificate with VA and visual field measurements before undergoing a driving test. Of note is the results that 43 (29.7%) out of 145 drivers using spectacles reported a history of RTAs. This suggests that these drivers could be wearing outdated or incorrect prescriptions. This assertion is supported by the fact that a significant proportion of drivers reported that they had never had a comprehensive eye examination for more than 2 years. In addition, this could be indicative of other causes of RTAs besides the visual aspect.

More than one-quarter (28%) of the drivers reported having previously been involved in RTAs while driving, with the majority of these being male drivers (84.6%). This prevalence is higher than the 22.5% obtained by Boadi-Kusi et al.[14] in Ghana but lower than the 45.5% reported by Pepple and Adio[22] in Nigeria and the 43.7% reported by Moledi and van Staden[16] in Lesotho. The marked disparity among these studies can be because of the differences in the study populations. For instance, our study included both light and heavy motor vehicle drivers, while other studies included commercial drivers only. The finding that male drivers had twice the odds (OR = 2.237, P = 0.002) of being involved in RTAs than female drivers could be a reflection of risk-taking behaviour in male drivers. The finding that the highest number of accidents were among the 35–59 age group could be because of the cohort effect, as this group constituted the highest number of participants (353 out of 579). It is not clear why a significant number of accidents were reported among drivers with more years of driving experience.

Seventy-four (12.8%) drivers admitted to taking alcohol while on duty, of whom 29 (39.2%) drivers had a history of road accidents. Alcohol has been reported to be a major contributor to the burden of RTAs and injuries in South Africa, accounting for at least 27.1% of all driver-error-attributed fatal crashes.[31] The overall road crash fatality rate in South Africa is 25.9 deaths per 100 000 – approximately 1.5 times the global rate.[32] Alcohol intoxication causes deterioration in cognitive functioning and psychomotor skills resulting in a slower response to driving hazards and judgement, thus increasing the risks of crashes and injuries.[33] This assertion is supported by the findings of this study, which showed that drivers who consume alcohol on a normal working day had higher odds of being involved in RTAs than drivers who did not (OR = 1.80, 95%CI = 1.09–2.99, P = 0.023). Of even greater concern is that among the drivers with a history of RTAs, the majority acknowledged the possible compromised visual status because of alcohol intake. These drivers continued to drive, potentially posing a safety risk to themselves and others on the road. The *National Road Traffic Act of 1996* contains specific measures on restricting drink driving or drunk driving with proposed amendments to adopt a zero-blood alcohol content limit through the Road Traffic Amendment Bill.[34] The National Road Safety Strategy 2016–2030 focuses on the high levels of involvement of alcohol in RTAs, the weakness of law enforcement and the prosecution of intoxicated drivers.[35] There is a need for the enforcement of these frameworks to implement the zero-tolerance drink-driving legislation, which is an important public health-oriented opportunity for the control of alcohol-related harm in South Africa.[36]

Visual acuity is one of the visual parameters included in the current Regulation 102. Sixty-nine (15%) out of 459 heavy motor vehicle drivers presented with vision less than the current South African minimum required VA of 0.2 LogMar (6/9 Snellen acuity) (Table 2a). Twenty-one (30.4%) of the 69 drivers with less than 0.2 LogMar indicated a history of RTAs. The current VA requirement for LMVs is a minimum of 0.3 LogMar (6/12 Snellen acuity) binocularly or a minimum of 0.2 LogMar in the better-seeing eye when the worst eye is either blind or worse than 0.3 LogMar (6/12). Considering these minimum VA requirements for LMVs, 5 (4%) drivers out of 120 LMV drivers did not meet the current South African VA requirement for driving in this category. These findings are in agreement with previous investigations on Saudi Arabian drivers (3.4%),[37] Nigerian drivers (3.3%)[18] and Ghana drivers (2.5%)[14] but less than the 6.8% reported in another Ghanaian study.[38] Three (60%) out of five participants who did not meet the current VA requirements for driving reported a positive history of RTA. There was a statistically significant association between VA and involvement in RTA (OR = 1.427, 95%CI = 0.988–2.061, P = 0.058). These results indicate that there are drivers who were issued driver's licenses without meeting the minimum VA requirements. Of the five drivers who did not meet the minimum requirements, four reported having tested their eyes at a DLTC site and one at an optometric practice. There is a need for appropriate testing protocols to be followed at both DTLC and optometric practices to ensure that it is safe for them to drive their vehicles on the road.

Although studies on the association between visual field and RTAs have yielded conflicting results.[39] There is evidence that drivers with visual field defects have a higher incidence of RTAs.[40] In this study, there was no significant association between visual field defects and RTAs. This result agrees with the studies conducted by Oladehinde et al.[18] and Pepple and Adio[22] in Nigeria. Another study,[19] however, found a significant association between visual field defect and RTA. The reasons for this discrepancy among the studies remain unclear. It cannot be explained by the differences in the tools used to measure VF. For instance, both Oladehinde et al.[18] and Pepple and Adio[22] used automated perimetry and our study used manual arc perimetry/disc (Bernell Vision Disk) but all these studies reported that visual field anomalies were not statistically significantly associated with RTAs.

Refractive error affected 486 (83.9%) drivers, which is higher than the 60% reported among drivers in Ghana,[14] 48.3% in Saudi Arabia[37] and 38.91% in Lesotho.[16] This suggests that there may be a higher prevalence of refractive errors among South African drivers as the definition of refractive error was similar in all three studies. There was a statistically significant association between poor vision because of refractive error and the occurrence of RTAs (χ^2 = 61.5667, P = 0.033). As our study showed a significant association between poor vision because of refractive error and the occurrence of RTAs, corrective lenses can improve the vision of these drivers and minimise the possibility of RTAs. There is a need to emphasise the importance of good vision when driving. Our results are comparable with a previous study, which showed a significant association between the refractive error and the RTAs among Nigerian drivers.[18]

Colour vision defects affected 11.2% of the drivers in our study, which is significantly higher than the 4.5% reported among Nigerian drivers,[18] 2.39% reported among 460 drivers in Lesotho,[16] and 1.6% seen in 249 sampled drivers in Southwest Ethiopia.[41] The difference between our study and the above-mentioned studies may be because of the differences in instruments used. For example, this study utilised the HRR pseudo-isochromatic plate and the other studies used the Ishihara pseudo-isochromatic plates, which are only sensitive to congenital defects. The HRR can reveal both congenital and acquired defects, identify the type of defect and diagnose the extent of the defect as well as quick positive classification of normals. A significant proportion (35.4%) of drivers with CV defects in this study reported a history of road accidents (Table 2a and Table 2b) with deutans more likely to be involved in RTAs compared to protans and tritans (χ^2 = 31.42, P = 0.002). Emerole and Nneli[42] reported that CV defects may compromise safe driving because of difficulty in identifying road signs and seeing traffic lights and signals from other cars. Colour vision is not included in the vision testing protocols for driving in many countries including South Africa.

The results of this study suggest the need to include CV testing among visual function tests for drivers.

There was no statistically significant association between reduced stereopsis and RTAs (OR = 1.001, 95%CI = 0.999–1.003, $P = 0.347$), which is similar to other reports by Boadi-Kusi et al.,[14] Oladehinde et al.[18] and Ovenseri-Ogbomo and Adofo.[38] However, 26 of the 82 drivers with abnormal stereopsis reported a positive history of RTAs. This suggests that abnormal stereopsis may create difficulty in judging distance correctly when driving. The effects of stereopsis on driving performance can, therefore, not be ignored. Boadi-Kusi et al.[14] found similar results in their study and suggested further investigations to understand the contribution of stereopsis to RTAs.

Contrast sensitivity has been reported to predict the driver's ability to see oncoming targets or stationary objects at the first possible moment and is, therefore, associated with a history of RTAs.[24] Among the 81 (14%) drivers who failed the CS test in this study, 26 (32%) reported being involved in RTAs. In addition, there was a statistically significant association between CS and RTAs (OR = 0.531, 95%CI = 0.305–0.925, $P = 0.025$), similar to a previous report.[24] This study suggests the inclusion of CS as part of the drivers' vision testing in the country to improve the safety of the driver and others in terms of detecting and recognising objects at reasonable distances in a short time. Twenty-eight (32.2%) of the 87 (15%) drivers with abnormal glare sensitivity reported a positive history of RTAs. This suggests that glare from oncoming traffic lights affects the drivers' vision, thereby introducing risks to driving safety because of the loss of visibility or discomfort. The loss of visibility or discomfort is because of luminance in the visual field greater than the illuminance to which the eyes are adapted.[14] This is supported by the fact that there was a statistically significant association between glare sensitivity and CS (OR = 0.932, 95%CI = 0.910–0.955, $P = 0.000$) and that 93.6% of the drivers knew that individuals have difficulty driving at night because of oncoming traffic lights.

Of the 579 drivers, 150 (25.9%) drivers had pinguecula and 91 (15.7%) drivers had pterygia, possibly because of ultraviolet exposure and further aggravated by wind and dust. These results are similar to those reported by Pepple and Adio[18] in Nigeria. It is suggested that drivers wear good-quality sunglasses to minimise the flare-ups and symptoms associated with these conditions. A total of 58 (10%) drivers had cataracts, 17 (29.3%) of whom had a history of RTAs. Thirty (5.2%) of the total 579 drivers were found to have glaucoma, 10 (33.3%) of whom reported a history of RTAs. Moledi and van Staden[16] reported higher cataracts and glaucoma prevalence figures of 4.79% and 1.09%, respectively, among 460 licensed drivers in Lesotho. These common ophthalmic conditions require appropriate interventions (medical, surgical and optical) to enhance visual performance and improve road safety, as 29.3% and 33.3% of those with cataracts and glaucoma, respectively, reported a history of RTAs. This study is a cross-sectional design and limits its ability to infer causality between visual functions and RTAs.

Conclusion

A substantial number of drivers never had a vision assessment before the issuance or renewal of licenses, and a significant proportion of poor vision was because of uncorrected refractive errors. Drivers need to have their eyes tested before the issuance or renewal of licenses to identify visual function problems and manage them appropriately. There is a significant relationship between RTAs and alcohol consumption, poor VA, refractive errors, deutan CV defect and abnormal CS but none between RTAs with visual field defect, abnormal stereopsis and glare sensitivity among drivers in Gauteng, South Africa. The inclusion of CV and CS in the battery of vision tests for drivers and strengthening the laws about drink driving can minimise the risks of RTAs.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

G.T.T., T.A.R. and K.P.M. were responsible for the conception or design of the work, the drafting of the manuscript and the data collection. G.T.T., T.A.R. and K.P.M. contributed to the critical revision and the final approval of the article.

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Data availability

The data that support the findings of this study are available from the corresponding author, K.P.M, upon reasonable request.

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Appendices starts on next page →

Appendix 1

Part 1: Interview schedule for drivers.

Please indicate the correct response for each of the questions below.

Section A: Demographics information

Participant code__________________

1. Gender: Male ☐ Female ☐
2. Age ________________________
3. What is your highest level of education?

   No formal education ☐ Primary ☐ Middle/ High School ☐ Secondary/Technical ☐ Tertiary/Post-Secondary ☐

Section B: Driving experience

4. How long have you been a licensed driver? __________________________________
5. When was the last time you renewed your driver's license? _____________________
6. Do you have advanced driving training/ skills? Yes ☐ No ☐
7. How frequently do you drive?

   Daily ☐
   Almost every day ☐
   A few days a week ☐
   Few days a month ☐
   A few times a year ☐
   Never ☐
8. What distance range do you usually drive per day? (Choose the option that best describes your distance range)

   Short distance (50 – 200 km round trip) ☐
   Middle distance (201 km – 500 km round trip) ☐
   Long-distance (> 500 km round trip) ☐
9. What is the purpose of your driving? Private ☐ Commercial ☐
10. Do you have a PDP (Public / Professional Drivers Permit)? Yes ☐ No ☐
11. Which driving License Code do you currently have?

    Code A ☐ Code A1 ☐ Code B ☐ Code C ☐
    Code C1 ☐ Code EB ☐ Code EC ☐ Code EC1 ☐
12. When last did you have a full eye examination? Choose from the options below

    1 year ago, ☐
    2 years ago, ☐
    More than 2 years ☐
13. Do you go through an eye examination before renewing your license? Yes ☐ No ☐
14. Where do you usually have your eye examination for the renewal of your driving license?

    Driving license testing centre ☐ Optometrist ☐ Ophthalmologist ☐
    Other (specify) ☐ ____
15. Do you have spectacles or contact lens restrictions on your driver's license?

    Yes ☐ No ☐
16. Do you have any of the following eye conditions?

    None ☐ Cataract ☐ Diabetic Eye Disease ☐ Glaucoma ☐ Macular Degeneration ☐ I don't know ☐
    Other (specify) ☐ _______________________________

    If you answered "None" or "I don't know", above go to question 16

17. Are you receiving treatment for any of the above eye conditions? Yes ☐ No ☐
18. If you have Diabetes, what type is it?
    Type 1 ☐ Type 2 ☐ I don't Know ☐ Others________________________________
19. Do you know that people with Type 1 diabetes are prone to fainting while driving if uncontrolled?
    Yes ☐ No ☐
20. Can you easily identify **all the colours** of the traffic lights? Yes ☐No ☐
21. If no in question 20, are you colour deficient (some call it colour blind)?
    Yes ☐ No ☐
22. If no in question 20, which colours do you have difficulty identifying? ___________________
23. Are you aware that some individuals cannot differentiate between colours?
    Yes ☐ No☐
24. Do you have difficulties judging distances correctly when driving? Yes ☐ No☐
25. Are you aware that some individuals cannot judge distances correctly when driving?
    Yes ☐ No ☐
26. Do you have difficulty driving at night because of glare from incoming traffic lights?
    Yes ☐ No ☐
27. Are you aware that some individuals have difficulties driving at night because of glare from oncoming traffic lights?
    Yes ☐ No ☐
28. Have you ever been involved in any road accident while driving?Yes ☐ No ☐

If no in question 28, please go to question 31

29. How many years ago did the accident occur? ____________________
30. What was the cause of the accident?
    Difficulty seeing road signs or traffic lights ☐
    Lack of proper judgement of the distance between your car and the other car ☐
    Dazzling lights ☐ Defective lights ☐ Overloading ☐ Mechanical failure ☐
    Skid and road surface defect ☐ Level crossing and obstruction ☐ Alcohol Related☐
    Other (specify) ☐____

Section C: Alcohol Intake Status

31. Do you take alcohol on a normal working day? Yes ☐ No ☐
32. How often do you drink alcohol?
    I have never drunk alcohol ☐ I no longer drink alcohol ☐ I drink alcohol very rarely ☐
    Less than once a week ☐ 1 or 2 days a week ☐ 3 or 4 days a week ☐
    5 or 6 days a week ☐ Every day ☐

If no in question 28, go to question 32

33. For how long have you been drinking alcohol? _________________
34. How many drinks do you have on a typical day when you are drinking? (Drink = Small glass of wine, 330 mL can of regular beer, a tot of spirits, or a mixed drink.)
    1 or 2 drinks ☐ 3 or 4 drinks ☐ 5 to 6 drinks ☐ 7 to 8 drinks ☐
    9 to 12 drinks ☐ 13 or more drinks ☐
35. Does your intake of alcohol affect your driving skills? Yes ☐ No ☐

36. Do you know that continuous alcohol intake can affect your ability to differentiate between the colours of the traffic light?
    Yes ☐ No ☐
37. Do you know that alcohol intake can affect your ability to judge distances properly? Yes ☐ No ☐
38. Do you know that alcohol intake can affect your ability to see oncoming traffic lights at night?
    Yes ☐ No ☐

Thank you for your participation

Appendix 2

Drivers Record Card

Participant code________________________

Rx wearer: ☐ No Rx wearer: ☐

Visual Acuity

	Unaided		Habitual		Pinhole VA<6/12	
	OD	OS	OD	OS	OD	OS
Distance						
Near						

Habitual Rx: SV-Dist ☐ SV-Near☐ BF☐ MF☐ CL☐

OD: ________________________

OS: ________________________

ADD: ________________________

Colour Vision HRR Test

OD: ________________________

OS: ________________________

Prebyopic Status

Presbyopic ☐ Non- Presbyopic ☐

Stereopsis Near Randot - Test

____

Auto- Refractor

OD: ________________________

OS: ________________________

Tentative Add: ________________________

Near VA: OD______________ OS:______________

Visual Fields Vision Disc

	OD	OS	OU
		`	

Cover Test Phoria ☐ Tropia ☐

Unilateral ☐ Alternate☐

	Horizontal	Vertical
Dist.		
Near		

Measured Deviation________________________

IOP I-Care Tonometer

OD: ________________________mmHg

OS: ________________________ mmHg

Time: ________________

Contrast Sensitivity Mars Chart

OD: ________________________

OS: ________________________

OU: ________________________

Glare Sensitivity Photostress Test

OD: ________________________sec

OS: ________________________ sec

Ocular Health Examination Ophthalmoscopy

Ocular Structure	Normal			Abnormal		
	OD	OS	OU	OD	OS	OU
Lids and Lashes						
Conjunctiva						
Sclera						
Cornea						
Iris						
Pupils						
Anterior Chamber						

If abnormal, Specify

☐Entropion ☐ Ectropion ☐ Trichiasis ☐ Poliosis ☐Ptosis

☐Chalazion ☐ Stye ☐ Pterygium ☐ Pinguecula

☐Redness ☐Arcus senilis ☐ Keratitis ☐Corneal opacity/scar

☐ Keratoconus ☐Subconjunctival Haemorrhage

☐ Other Conjunctivitis: ________________________

Internal Eye Examination

Ocular Structure	Normal			Abnormal		
	OD	OS	OU	OD	OS	OU
Lens						
Vitreous						
Disc						
Macula						
Blood Vessels						
Retina						

If abnormal, Specify

☐ Vitreous Haemorrhage ☐ Uveitis ☐ Cataract

☐ Glaucoma/ Suspect ☐ Optic Atrophy ☐ Macular scar

☐ Toxoplasmosis ☐ Retinopathy: ________________

☐ Other: ________________________

Contrast Sensitivity

Mars Chart

Row	FORM 1	Left eye ☐	Right eye ☐	Binocular ☐		
1	C ☐ 0.04	H ☐ 0.08	V ☐ 0.12	O ☐ 0.16	S ☐ 0.20	N ☐ 0.24
2	D ☐ 0.28	S ☐ 0.32	Z ☐ 0.36	N ☐ 0.40	R ☐ 0.44	K ☐ 0.48
3	N ☐ 0.52	D ☐ 0.56	R ☐ 0.60	H ☐ 0.64	V ☐ 0.68	Z ☐ 0.72
4	C ☐ 0.76	S ☐ 0.80	O ☐ 0.84	N ☐ 0.88	K ☐ 0.92	H ☐ 0.96
5	K ☐ 1.00	N ☐ 1.04	V ☐ 1.08	D ☐ 1.12	S ☐ 1.16	R ☐ 1.20
6	Z ☐ 1.24	R ☐ 1.28	D ☐ 1.32	K ☐ 1.36	H ☐ 1.40	O ☐ 1.44
7	H ☐ 1.48	Z ☐ 1.52	C ☐ 1.56	V ☐ 1.60	R ☐ 1.64	K ☐ 1.68
8	S ☐ 1.72	C ☐ 1.76	Z ☐ 1.80	D ☐ 1.84	V ☐ 1.88	O ☐ 1.92

log CS value at final correct letter: _____

Number of errors prior to final correct letter _____X 0.04 = _____

Subtract

log Contrast Sensitivity _____

Row	FORM 2	Left eye ☐	Right eye ☐	Binocular ☐		
1	K ☐ 0.04	S ☐ 0.08	H ☐ 0.12	O ☐ 0.16	N ☐ 0.20	C ☐ 0.24
2	Z ☐ 0.28	D ☐ 0.32	C ☐ 0.36	R ☐ 0.40	V ☐ 0.44	O ☐ 0.48
3	C ☐ 0.52	K ☐ 0.56	O ☐ 0.60	N ☐ 0.64	R ☐ 0.68	S ☐ 0.72
4	N ☐ 0.76	S ☐ 0.80	Z ☐ 0.84	K ☐ 0.88	H ☐ 0.92	D ☐ 0.96
5	H ☐ 1.00	N ☐ 1.04	C ☐ 1.08	O ☐ 1.12	R ☐ 1.16	Z ☐ 1.20
6	V ☐ 1.24	K ☐ 1.28	S ☐ 1.32	N ☐ 1.36	D ☐ 1.40	R ☐ 1.44
7	K ☐ 1.48	R ☐ 1.52	V ☐ 1.56	Z ☐ 1.60	O ☐ 1.64	S ☐ 1.68
8	V ☐ 1.72	Z ☐ 1.76	C ☐ 1.80	D ☐ 1.84	V ☐ 1.88	H ☐ 1.92

log CS value at final correct letter: _____

Number of errors prior to final correct letter _____X 0.04 = _____

Subtract

log Contrast Sensitivity _____

Row	FORM 3	Left eye ☐	Right eye ☐	Binocular ☐		
1	H ☐ 0.04	R ☐ 0.08	Z ☐ 0.12	V ☐ 0.16	C ☐ 0.20	N ☐ 0.24
2	S ☐ 0.28	O ☐ 0.32	K ☐ 0.36	D ☐ 0.40	R ☐ 0.44	S ☐ 0.48
3	K ☐ 0.52	D ☐ 0.56	C ☐ 0.60	V ☐ 0.64	O ☐ 0.68	H ☐ 0.72
4	N ☐ 0.76	S ☐ 0.80	O ☐ 0.84	Z ☐ 0.88	C ☐ 0.92	D ☐ 0.96
5	R ☐ 1.00	H ☐ 1.04	N ☐ 1.08	K ☐ 1.12	Z ☐ 1.16	O ☐ 1.20
6	C ☐ 1.24	R ☐ 1.28	S ☐ 1.32	V ☐ 1.36	K ☐ 1.40	N ☐ 1.44
7	S ☐ 1.48	K ☐ 1.52	R ☐ 1.56	N ☐ 1.60	H ☐ 1.64	D ☐ 1.68
8	C ☐ 1.72	V ☐ 1.76	H ☐ 1.80	D ☐ 1.84	O ☐ 1.88	Z ☐ 1.92

log CS value at final correct letter: _____

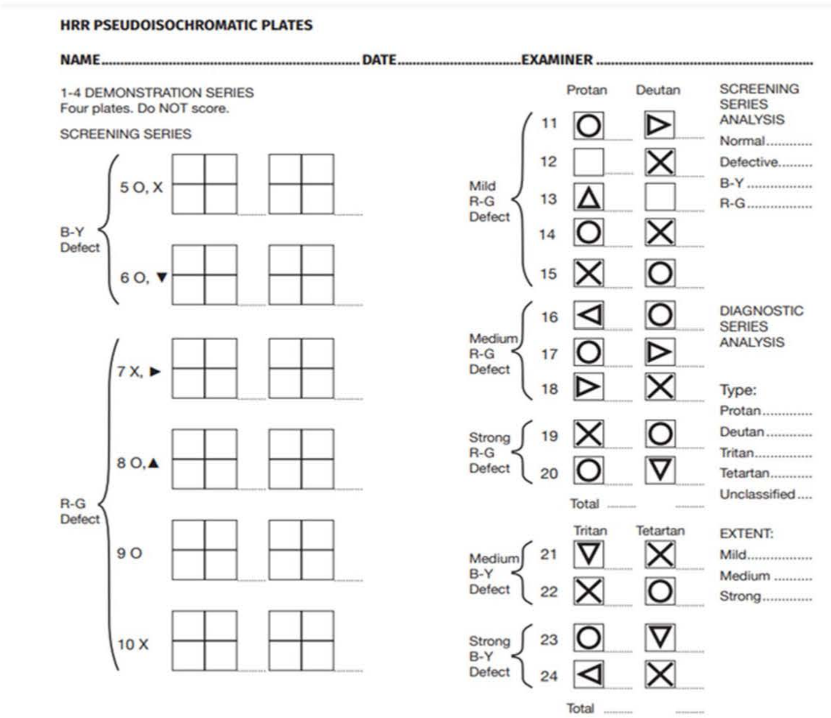
Number of errors prior to final correct letter _____X 0.04 = _____

Subtract

log Contrast Sensitivity _____

Colour vision

HRR Colour Vision



Action taken: ☐ None indicated ☐ Referred for Ophthalmology attention

☐ Referral for Optometrist attention ☐ Spectacle for reading ☐ Spectacle for distance

☐ Prescribed Eyedrops ____

☐ Provided Eye Test Certificate #:____