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Review Article

Reviewing the prevalence of refractive errors and color blindness among commercial drivers

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ABSTRACT

Road traffic crashes pose a significant global public health concern, claiming the lives of approximately 1.19 million people each year. A worrisome trend surfaces as a considerable majority of these fatalities involve vulnerable road users, encompassing not only drivers of heavy and light vehicles but also pedestrians, cyclists, and motorcyclists. Visual impairments play a significant role in these tragic events, further exacerbating the risks faced by road users. Whether due to poor eyesight or other vision-related challenges, impaired visual perception contributes to the vulnerability of individuals on the road. This review aimed to systematically analyze the currently available research and articles to determine the prevalence of color vision defects and refractive errors among commercial drivers.
The primary objective was to investigate whether refractive errors and color vision defects pose a risk factor for road safety among commercial drivers. A primary search of databases including PubMed, Google Scholar, and others was conducted using relevant keywords. Articles published between 2010 and 2023 were considered, resulting in 16 cross-sectional studies being included for analysis. Prevalence rates were calculated using weighted averages based on sample sizes. Among commercial drivers, the prevalence of color vision impairment was lower (4.35%) compared to refractive errors (23.42%). Individuals with protanopia were at higher risk of road traffic accidents (RTAs). Complex issues such as alcoholism and visual impairments contributed to higher RTA frequencies in certain populations, emphasizing the multifaceted nature of road safety challenges.

Keywords: Color vision defects, Color blindness, Prevalence, Refractive error, Traffic signals

INTRODUCTION

Human color vision is trichromatic, relying on the mixture of red (60%), green (30%), and blue (10%) lights. Each set of cones is responsible for detecting specific wavelengths, contributing to the richness of our visual experiences. However, color blindness arises when there are defects in one or more of these three sets of cones, disrupting the harmonious interplay required for accurate color perception. Typically, color blindness is congenital, meaning individuals are born with this condition. It often goes undetected, and many people may not even be aware of their color blindness due to a lack of acknowledgment or understanding of the subtle nuances in their perception of colors.[1] This lack of awareness can be attributed to the fact that individuals with color vision deficiencies may compensate for their limitations by relying on contextual cues or patterns. Moreover, color blindness exhibits a notable gender bias, affecting males more frequently than females. This predisposition is rooted in the genetic inheritance of the X chromosome, where the genes responsible for color vision are located. As males possess only one X chromosome, a mutation in the corresponding gene on that chromosome can result in color blindness. In contrast, females, with two X chromosomes, have a greater chance of compensating for such mutations.[2] In India, Nigeria, and Pakistan, the visual acuity requirement in the better eye to issue a driving license is 6/12, and there is a color vision requirement. Similarly, Turkey and Ghana have a visual acuity requirement of 6/9, and they also mandate a color vision requirement for issuing driving licenses. India, Nigeria, Turkey, Pakistan, and Ghana. Visual acuity, typically measured as the Snellen fraction, indicates the clarity or sharpness of vision. A measurement of 6/12 means that a person can see at 6 meters what a person with normal vision can see at 12 meters. In all listed countries, the minimum visual acuity required in the better eye for obtaining a driver's license is 6/12 or better. This standard ensures that drivers have adequate vision to safely operate vehicles on the road, though there might be slight variations in the exact measurement depending on the country's regulations.

Additionally, all countries mentioned require passing a color vision test as part of the driver's license application process. Color vision is crucial for interpreting traffic signals, signs, and other essential visual cues while driving. Ensuring that drivers have normal color vision helps mitigate the risk of misinterpreting important information on the road, thereby contributing to overall road safety. It is notable that the standards for visual acuity and color vision requirements are fairly consistent across these countries. This consistency likely reflects internationally recognized standards and best practices in traffic safety and driver licensing. However, while these requirements are essential for ensuring road safety, it's also crucial for drivers to undergo regular vision screenings to maintain safe driving abilities throughout their lives, as vision can change over time due to various factors such as age, injury, or illness.[3] In addition to color blindness, another common visual impairment is refractive error. Refractive errors occur when the shape of the eye prevents light from focusing directly on the retina, resulting in blurred vision. The main types of refractive errors include myopia (nearsightedness), hyperopia (farsightedness), astigmatism, and presbyopia. Myopia occurs when the eyeball is too long or the cornea is too steep, causing light to focus in front of the retina instead of on it. This results in distant objects appearing blurry, while close objects remain clear. Hyperopia, on the other hand, occurs when the eyeball is too short or the cornea is too flat, causing light to focus behind the retina.

As a result, close objects may appear blurry, while distant objects may be seen more clearly. Astigmatism arises from an irregular curvature of the cornea or lens, causing light to focus unevenly on the retina. This can lead to distorted or blurred vision at all distances. Presbyopia is an age-related condition that occurs when the lens of the eye loses its flexibility, making it difficult to focus on close objects, especially when reading or performing tasks at close range. Like color blindness, refractive errors can also affect individuals' daily activities, including driving, reading, and using electronic devices. They can often be corrected with prescription eyeglasses, contact lenses, or refractive surgery, thereby improving visual acuity and overall quality of life.[4] Color vision deficiency (CVD) is a prevalent condition worldwide, with varying rates reported across different studies and populations. In India, several cross-sectional studies have investigated the prevalence of CVD among diverse demographic groups. For instance, Rajendra et al conducted a study involving 140 participants, reporting no cases of CVD but identifying refractive errors in 28.57% of the sample.[5] Mukesh et al found a CVD prevalence of 3.9% among 281 participants, with 15.7% exhibiting refractive errors.[6] Similarly, Xavier et al (2014) identified a CVD prevalence of 2.02% in 148 participants, with refractive errors noted in 31.08% of cases.[7] Slathia et al, in a study of 140 individuals, reported no cases of CVD and found refractive errors in 17.14% of participants (Slathia et al).[8] In contrast, Sabherwal et al conducted a large-scale study involving 4059 individuals in India, focusing on refractive errors with no specific data on CVD prevalence available.[9] Sharma et al studied 56 participants, reporting a 5.1% prevalence of refractive errors without mentioning CVD.[10] Verma et al surveyed 1041 individuals, identifying a CVD prevalence of 1.3% alongside refractive errors in 18.82% of cases.[11] Studies from other regions have also contributed to the understanding of CVD prevalence. For instance, in Pakistan, Samaira Faiz et al. (2019) reported a CVD prevalence of 3% among 300 participants, although refractive error data was not specified (Faiz et al).[12] Similarly, in Turkey, Mohammad Ghasemi et al found a CVD prevalence of 2% among 200 participants, alongside refractive errors in 15% of cases (Ghasemi et al).[13] These studies underscore the variability in CVD prevalence across different populations and highlight the importance of understanding regional differences in assessing and managing color vision deficiencies.

METHODS

This article was meticulously crafted through an extensive primary search conducted across various reputable platforms including PubMed, Google Scholar, Medline, National Institute of Health, and other scholarly journal sites. Utilizing a strategic combination of keywords such as color vision, color vision deficiency, color blindness, drivers, road safety, and traffic signals, a comprehensive collection of relevant literature spanning from 2010 to 2023 was amassed. Initially, a total of 34 articles were identified, which were then meticulously narrowed down to 22 based on the publication year criteria. Subsequently, from this refined subset, 16 cross-sectional studies were meticulously selected for inclusion in this review. This selection process was undertaken with careful consideration of factors such as the availability of full-text articles and the publication year. Prevalence rates of various aspects related to color vision deficiency were computed using a meticulous weighted average approach, taking into account the sample sizes of each study. Through this rigorous methodology, this review aims to provide a comprehensive synthesis of the latest research findings pertaining to color vision deficiency and its implications for drivers and road safety

RESULTS

The statistics indicated a lower prevalence of color vision impairment (4.35%) among commercial drivers, while a contrasting trend was observed with refractive errors, showing a higher occurrence at 23.42%. Significantly, individuals with protanopia, a type of color blindness, were reportedly at a heightened risk of encountering road traffic accidents (RTAs) compared to those with other forms of color vision deficiencies. This underscored the importance of understanding the specific risks associated with different types of visual impairments in the context of road safety. The assertion that Nigerians experienced a higher frequency of RTAs compared to other populations due to alcoholism and visual impairments raised complex issues related to public health and safety. While alcohol consumption could indeed contribute to impaired driving and increased accident risks, it was crucial to recognize the multifaceted nature of road safety challenges. In examining the nexus between visual impairments and RTAs, it was essential to delve into the specific nature of visual deficiencies prevalent among drivers.

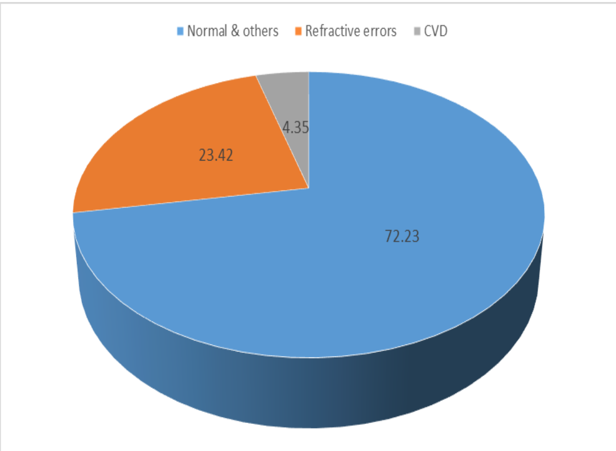

Figure 1: Prevalence of refractive errors and CVD.

Total sample size

Total sample size=∑sample size

Total sample size=140+281+148+140+4059+300+200+56+1041+400+206+524+291+520+200+148

Total Sample Size = 10023

Prevalence for refractive error

Total refractive error prevalence=∑(sample size× refractive error prevalence)/total sample size

Total refractive error prevalence= (140×28.57)+(281×15.7)+(148×31.08)+(140×17.14)+(4059×26.4)+(300×Not specified)+(200×15)+(56×5.1)+(1041×18.82)+(400×8.4)+(206×6.8)+(524×11.6)+(291×26.1)+(520×38.8)+(200×15.3)+(148×45.9)/Total Sample Size.

Prevalence for color vision deficiency

Total color vision deficiency (CVD) prevalence =∑(sample size×CVD prevalence)/total sample size

Total CVD prevalence=(140×0)+(281×3.9)+(148×2.02)+(140×0)+(4059×not specified)+(300×3)+(200×2)+(56× Not specified)+(1041×1.3)+(400×4.5)+(206×3.4)+(524× Not specified)+(291×2.2)+(520×7.1)+(200×2.2)+(148×25)/total sample size.

We will assume a prevalence of 0% for "Not specified" in the absence of specific information.

Total refractive error prevalence=(140×28.57)+(281×15.7)+(148×31.08)+(140×17.14)+(4059×26.4)+(300×0)+(200×15)+(56×5.1)+(1041×18.82)+(400×8.4)+(206×6.8)+(524×11.6)+(291×26.1)+(520×38.8)+(200×15.3)+(148×45.9)/10023.

Total refractive error prevalence: approximately - 23.42%

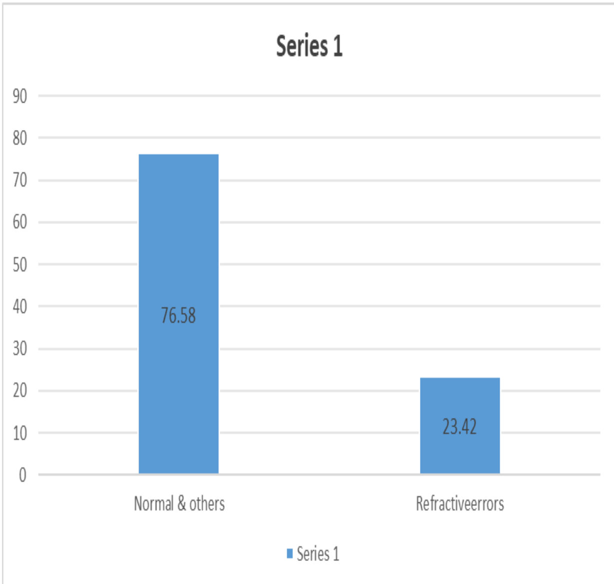

Figure 2: Prevalence refractive errors.

Total CVD prevalence=(140×0)+(281×3.9)+(148×2.02)+(140×0)+(4059×0)+(300×3)+(200×2)+(56×0)+(1041×1.3)+(400×4.5)+(206×3.4)+(524×0)+(291×2.2)+(520×7.1)+ (200×2.2)+(148×25)/10023

Total color vision deficiency prevalence: approximately -4.35%

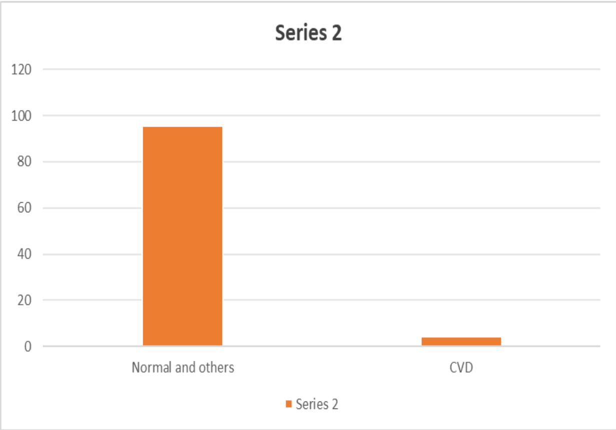

Figure 3: Prevalance of CVD.

DISCUSSION

The collective findings from multiple studies on the visual health of commercial and truck drivers underscore the urgent need for interventions to enhance road safety. The prevalence of refractive errors, visual impairments, and their associations with road traffic accidents (RTAs) emphasize the importance of routine eye examinations. The alarming statistic that one in two commercial drivers in Nigeria has been involved in an RTA calls for immediate attention, suggesting the necessity of measures such as penalization for substance use while driving and routine blood alcohol content (BAC) measurements. Nigerian authorities should, therefore, revise their protocols for issuing driving licenses.[14] Barriers to accessing eye care services, especially in the 41-60 age group, highlight the need for targeted health education programs. Samaira et al suggested the need for the modification of signal shape coding.[12] Ghasemi et al mentioned the absence of regular eye examinations in the military and commercial drivers Additionally, the findings stress the significance of revising vision standards, implementing legal requirements for regular eye examinations, and developing effective models for spectacle delivery to improve overall road safety.[13] The implications of these findings extend beyond individual drivers to broader road safety policies and practices. Recommendations include revising criteria for vision requirements in driving tests, implementing routine eye examinations as part of licensing procedures, and prioritizing regular monitoring of visual health for all drivers. Moreover, there is a clear need for collaborative efforts between healthcare professionals, regulatory authorities, and stakeholders in the transportation sector to implement evidence-based interventions aimed at promoting safer driving practices through improved visual health standards.[15]

However, other factors such as cataracts, corneal opacities, and anterior segment disorders were found to be common in commercial drivers but not of very high prevalence. The research also revealed a high number of individuals who had never undergone primary eye examinations before participating in the studies. This underscores the critical need for comprehensive eye care initiatives and increased awareness regarding the importance of regular eye check-ups among drivers.[16] The prevalence of refractive errors and color vision defects in commercial drivers in comparison to total sample size shown in Figure 1. The prevalence of refractive error in total sample size is shown in Figure 2. The prevalence of color vision defects in total sample size is shown in Figure 3.

CONCLUSION

The contrasting trends underscore the necessity for targeted interventions and awareness programs within the commercial driving sector. Addressing refractive errors and color vision defects is pivotal for enhancing the overall safety of road users. Our findings emphasize the importance of comprehensive eye examinations and corrective measures for commercial drivers, acknowledging the specific risks associated with different visual impairments. Furthermore, the identified prevalence rates contribute valuable insights for policymakers, allowing them to tailor road safety regulations and interventions effectively. A holistic approach, considering both refractive errors and color vision defects, is essential for implementing measures that mitigate risks and improve the safety outcomes within the realm of commercial driving.

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