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Review Article

Impact of Eyes and Visual Functions in Safe Driving

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ABSTRACT

Driving is a high level of visual functions demanding occupation. The relationship of good visual function and driving safety are innately and unarguably linked and have a direct bearing on the incidence of road traffic accidents. A more practical approach to improve the efficacy of vision screening at licensure is to examine visual acuity screening test supplemented by other types of screening tests like contrast sensitivity, visual field, binocularity, color vision, processing speed, light and dark adaptation etc. These clinical tests have a large evidence basis for their relevance to driver safety and should be mandatory for obtaining and renewing the driving license. The individual who failed the initial screening should undergo a protocol based comprehensive evaluation by an Ophthalmologist or Optometrist if fit to drive in future. Visual acuity and other visual functions requirements for driving vary from country to country though most countries mandate visual acuity of 20/40 in the better eye with horizontal visual field of 120 degrees. But there is variation regarding provision of color vision, binocularity, contrast sensitivity and night vision tests. Nepal yet , has not strict rules regarding evaluation of visual functions for safe driving. But indeed, a local expert review board should determine the suitability to issue a normal driving license or a restricted driving license, a temporary or a permanent denial for those who partially or completely failed the vision specific requirements. Moreover appropriate modification of the existing laws and expedited implementation are mandatory to minimize visual functions related road traffic accidents which is an avoidable cause of mortality and morbidity.

Key Words: Aging, color vision, contrast sensitivity, driving performance, driving vision, road safety, road traffic accidents.

INTRODUCTION

Visual impairment alone can cause road traffic accidents [1]. The strictness of driving standards varies internationally. Vision and its related visual functions have significant impact on safe driving and to secure a safe traffic system. So in all cases of drivers, visual functions should me measured to minimize road traffic accidents [2]. The visual functions highlighted based on the literature review are field of view, color vision, contrast sensitivity, binocularity and ocular motility. Good visual acuity of 6/6 or better is not alone sufficient for safe driving. Driving is very visually demanding task and it affects an individual's quality of life if their driving license is withdrawn. Age related ocular changes and other functional deficiencies can affect driving [2].

Rationale of the study: A number of traffic violations and motor vehicle collisions might occur due to poor visual functions [3]. Optimum visual functions are needed for identifying road hazards, read signs and to see our dashboard [4]. The main aim of this mini review article is to bring awareness about common visual functions need and their significances for safe road driving. Such a study might enlighten the common vision related changes and problems to stay safe while driving any type of public or private vehicles. Ocular and visual functions examinations may be at the pre-employment screening stage, or when existing employees develop ophthalmic problems that may question their visual fitness for work [5]. Driving a vehicle or piloting an airplane is a key means by which individuals maintain independence and mobility. There are over millions of people who hold a driving license in different regions of the world. So policymakers have a responsibility to provide a framework or legislation to enable safe driving conditions for both drivers and other citizens [1, 2]. Eye care clinicians need to be able to counsel patients about the visual criteria for driving and other tasks, correct and maximize vision for professional standards. For these reasons, it is important that today's eye practitioners should be familiar with contemporary occupational visual standards .The author's aim is to highlight various ocular disorders which can affect our vision and ability to drive safely.

Methods: The study was done during the period of 26 June 2021 to 24 August 2021. In this mini review article, Google, Google Scholar and PubMed were searched for various terms like color vision, driving vision, driving performance, road safety etc. The original journal articles from 2000 to 2020 and a few books which included chapters related to driving vision and visual standards were taken as references. All relevant full text articles regarding visual functions requirements for safe driving were searched and included in this review.

Coronavirus and Safe Driving:

The novel Coronavirus can enter our body through our eyes, in addition to nose and mouth [6].So eye care and hygiene with protection is utmost important specially during driving time in COVID-19 pandemic. During travelling in any motor or vehicles, when someone infected with Coronavirus sneezes, coughs or even talks, he/she may spread droplets that contain viruses. Soon after we are most likely to breathe in those droplets and the virus can also enter our body through our eyes. Meanwhile the virus may land on our hand or fingers and we might touch our nose, mouth or eyes and later whole body may be infected with Coronavirus during travelling time [7]. Somebody may be wearing contact lenses as a mode of optical correction during driving. Usually contact lens users touch their eyes more frequently than people who don't wear it. There is some evidence that we can get COVID-19 by touching a surface contaminated with COVID-19 and then touching our eyes without washing our hands properly [8-10]. To prevent the risk from contact lenses during COVID-19, it should be daily cleaned and disinfected using multipurpose contact lens solution [11-13]. For all contact lens users, eye specialist's and contact lens practitioner's instructions should be followed strictly [14-15].

Ocular manifestation of COVID-19: Ocular manifestations caused by COVID-19 are usually rare. The literature shows that less than one percent of infected people experience eye irritation in the form of

conjunctivitis due to COVID-19[16, 9]. But luckily, a natural phenomenon of eye like frequent blinking and exchange of tears causes virus unlikely to stay and propagate on the eye surface long enough to cause ocular problems. During driving time, the ocular symptoms of COVID-19 might be redness, irritation, foreign body sensation, tearing and photophobia. So the lack of wearing eye protective devices might be associated with an increased risk of SARS Coronavirus transmission from other infected individuals. Coronavirus RNA has been found in tears of infected human being, so during driving covering eyes with goggles or a face shield should be worn along with face mask and gloves [8]. The displacement of the face mask or its incorrect fitting during driving could disperse air around eyes and air leaking could cause rapid evaporation of tears causing dry eyes with burning sensation [17]. To relieve such symptoms, frequent instillation of lubricating eye drops and blinking regularly during driving time may reduce the ocular discomfort due to dry eye.

Visual functions and safe driving

In Nepal, according to Motor Vehicle and Transport Management Act, 2049 (1993), there are some provisions relating to driving license [18]. It is said that a person who being eyesight weak, uses glasses but despite using glasses is not able to see in a normal manner. Similarly a person who is suffering from night blindness and other sight defects due to which he/she not being able to distinguish red, green, yellow colors can not drive motors [18].

Regarding visual functions and fitness to drive, the author Kotecha et al. have highlighted various legal visual standards required to drive in United Kingdom (UK) [19]. In UK, driving is recognized to be a visually intensive task and accordingly there is a legal minimum standard of vision required for all motorists. The individual who drive cars and other light vehicles need to be able to read a standard car number plate with character of 79 mm in height and 50 mm width, with both eyes open at a distance of 20.5 m in good light with visual correction if needed. This visual standard corresponds to 6/10 Snellen's acuity. Considering the visual field, individuals should have at least 120 degree on the horizontal using Goldmann III4e testing and no significant defect in the binocular field encroaching within 20 degree of fixation above or below the horizontal meridian. Similarly the individuals who drive large good vehicles and passenger carrying vehicles are required to have an uncorrected visual acuity of at least 3/60 in each eye and with refractive correction at least 6/9 in their better eye and 6/12 in their worst eye. In the visual field, there should be full binocular field of vision with no missed points in the central 20 degree. For racing purposes, a best corrected visual acuity of 6/6 both eyes together and visual field of 120 degree horizontally without significant defect within 20 degree above or below the horizontal meridian. Besides vision and visual field, all drivers should not have uncontrolled diplopia or blepharospasm. According to author, contrast sensitivity should also be measured in drivers as some ocular pathology like age related cataract and macular degeneration might cause reduced contrast sensitivity that could hamper driving ability [19].

Nigeria, one of the country from African continent has been a victim of highest mortality rates from road traffic accidents [20]. The authors Pepple and Adio on their research article have tried to acquire information for effective policy formulation to improve driving safety on Nigerian roads

[20].In their study, the eyes of 400 commercial drivers were examined with a mean age of 37.8 years. They found that 20% subjects did not undergo any prior driving test and only one third of those who had had a prior eye test. Among them 45.5% had been involved in road traffic accident with alcohol intoxication and driver fatigue significantly associated. But surprisingly visual impairment, visual field and color vision defect were not significantly associated with occurrence of road traffic accidents. In their study 38.7% had some form of ophthalmic complaints. The common ocular problems were like Pterygium (26.7%), Presbyopia (22.9%), Cataract (14%), Glaucoma (11.5%) and Refractive error (8.4%). Considering these clinical aspects authors suggested that appropriate medical, surgical and optical evaluation of all motor drivers is important to enhance their visual performance and to bring positive impact on safe driving performance. Similarly periodic comprehensive eye testing including automated visual field should be done with them from government hospital by trained ophthalmic medical personnel prior to issuance and renewal of driving license [20].

In an another literature review of vision measurability and it's impact on safe driving, the authors Thorslund and Strand have suggested that visual function measurement is important to secure a safe traffic system[21]. They had included a total of 128 scientific publications for their review article. Among those published articles, majority of the literatures suggested that good static visual acuity is not alone sufficient for safe driving and testing of visual functions should consists of several complementary tests like useful field of view, contrast sensitivity, color vision, binocularity, light and dark adaptation should be assessed for safe driving[21]. But the effect of decreased field of view on driving performance is not conclusive and some of the researchers argue that it does not involve any danger in traffic system and road accident. Again few studies reported poor driving performance among subjects with central visual field loss, but at the same time they were found to have fewer traffic related convictions. Some literatures argued that to some extent the degree of visual field loss can be compensated by driver's behaviours including head or eye turn and tilt or with chin movement. Among the techniques of visual field measurement, Integrated Visual Field (IVF) which quantifies the central binocular visual field by merging results from monocular fields should be applied. This technique is better than monocular visual field testing for predicting whether a driver is at risk of losing their license in future. Another important visual function which is contrast sensitivity is generally stable until the age of 50 years and later it decreases by 0.1 log unit per decade. Authors suggested that age related deterioration in contrast sensitivity has been associated with older drivers driving cessation or self regulation. Contrast sensitivity can be significantly affected by various ocular pathologies including cataract, glaucoma, macular degeneration, Parkinson's disease etc. and their link with impaired driving performance has been made in a number of studies. The authors mentioned that some studies have shown an increased risk of road accidents for older drivers with reduced contrast sensitivity while other studies failed to find a correlation or found only a weak association. However decline in contrast sensitivity has been shown ti impair the recognition of road signs and danger in traffic maneuvering and driving at night. Considering color vision, some researchers have shown weak evidence

that protons have higher road crash rates than do color normals. According to them, 20% of anomalous trichromats and 50% of dichromats admit to difficulty recognizing signal colors and approximately 14% of protons admit to difficulty seeing red signal lights. But some few researchers suggested an elevated risk related to color vision deficiency and particularly protan color deficiency has more difficulty in seeing red lights and is at greater risk of being involved in accidents [21].

For awareness of common vision related changes, their impacts and remedies, the author Mukamal has highlighted few clinical suggestions on her article [22]. She suggested that good visual function is essential for safe driving. For safety of it, several factors like visual acuity, visual field, color vision and contrast sensitivity should be within the acceptable limit. Even normal age related ocular changes like presbyopia, dry eye, cataract and macular degeneration can affect our vision and ability to drive safely. They cause gradual loss of vision and are less noticeable. So to be in safe condition, we should have regular eye examination specially after 40 years of age. If we have refractive error, their corrections with glasses or contact lenses should be up to date. In the same way, side mirrors of vehicles and headlights should be properly adjusted and if broken, it should be replaced to light the road area adequately [22].

Similarly there is a study by Kimlin et al. to seek the association between night time driving performance of older drivers (71.8+6.3 Years) and photopic, mesopic and glare based tests of visual function [23]. The result was that the overall driving performance score was significantly reduced by intermittent glare ($p=0.002$) and pedestrian detection decreased by 38% in the presence of intermittent glare ($p<0.001$). Overall driving scores were strongly associated with motion sensitivity ($p=0.001$) and mesopic high contrast visual acuity ($p=0.002$) rather than photopic or glare based tests. Motion sensitivity (29%) accounted for more than twice the variation in driving performance compared to photopic high contrast visual acuity (14%). So the authors concluded that glare might reduce several aspects of night time driving performance and highlighted the potential importance of visual function tests for assessing older driver's visual capacity to drive at night [23].

According to Ortiz et al., there is significant impact of age related vision changes on driving [24]. They conducted an examination to find out an association between age related vision changes and simulated driving performance. In their study, participants were assessed for visual acuity, contrast sensitivity, halos and intraocular stray light which can all degrade vision. The result showed that older drivers presented impairment in most visual parameters ($p< 0.05$) with stray light being the most significantly affected that would cause veiling luminance on the retina. The study suggested that stray light evaluation could be significant in driver's assessment especially at the onset of age related vision changes. Ortiz et al.described that aging triggers a series of changes in the ocular structures including a marked loss of lens transparency which causes a significant increase in light scattering by the eye's optical medias. Intraocular scattering produces a veil of stray light over the retina that causes disability glare due to loss of retinal image contrast. Severe impairment in contrast sensitivity is known to be significantly associated with at fault accident involvement. Although visual acuity is a standard test for licensing

purposes, it only presents a weak correlation with safety risk in older drivers. So visual acuity alone does not give an accurate prediction of a driver's ability to recognize hazards in all hazy conditions or light levels. Stray light is one of the main causes of glare complaints and clearly compromises contrast sensitivity specially in older drivers even in photopic conditions. In their study, comparison of visual functions measurement and driving performance outcomes were compared between younger (age 25-40 years) and older (age>55 years) drivers. As a result, authors found that older drivers, age greater than 55 years were found to have diminished visual acuity, poor contrast sensitivity and were influenced more by glare and halos [24].

In a scientific article from Honavar from India suggested that visual function tests are mandatory for driving license [25]. According to the author perceptual and cognitive functions that have an impact on driver's safety and driving performance include visual functions, auditory skills, biomechanical skills, speed judgment, reaction time and attention. In India drivers involved in road traffic accidents are not evaluated for visual functions which is a serious concern regarding suspected poor visual performance that might cause road traffic accident. Honavar further suggested that only a static visual acuity may not be good predictor of driving safety but other important component of visual functions like visual fields, color vision, contrast sensitivity, night vision, glare sensitivity, binocularity and stereopsis should be well evaluated for driving safety and performance. In India, in an average there occurs a road accident every minute and a death in every 3.5 minutes that clearly indicates the significance of evaluation of all visual functions in motor drivers. Author mentions that vision specific requirements for driving vary from country to country though most countries mandate visual acuity of 20/40 in the better eye and horizontal visual field of 120 degree. But there is variation regarding provision of color vision, contrast sensitivity, binocularity and night vision. In India, according to motor vehicle act (MVA) 1988 which was amended in 2017, specifies that a vehicle driver should be able to distinguish a motor car number plate from 25 meters which is approximately 20/40, able to distinguish red and green colors and should not have night blindness. Similarly monocular drivers should have visual acuity of 20/40 in the remaining eye with horizontal visual field of 120 degree with monocular adaptation period of six months. The author further has given an example of Australia where visual acuity of 6/12 and horizontal visual field of 120 degree is essential for private driving license and for commercial driving, visual acuity of 6/9 in the better eye and 140 degree horizontal visual field is required. Color vision except for protanopia is not mandatory for driving private vehicles. Honavar further advised that for older individuals, to be safe in driving in India, they must follow International College of Ophthalmologist's (ICO) vision requirements guidelines. ICO mandates that in older drivers with age greater than 65 years, testing of glare and contrast sensitivity should be considered and driving licenses should have a defined renewal period. For safe driving, the visual and driving performance of older drivers should be assessed regularly starting at the age of 65 years. ICO suggests restricted license to improve the safety margin for those who have prior driving experience and good driving record but failed the standard screening criteria. The suggested restrictions include

limitation to daylight driving, restriction to a reasonable radius from a home, restriction to familiar areas, speed limitation, no highway driving and more frequent retesting [25].

Regarding safe driving, according to Owsley and McGwin, it is highly visual demanding task [26]. Although visual acuity is a screening test during application for a driver's license, major other of functional vision and visual processing might play role in supporting the effective control of a vehicle. Visual standards for driver licensure need to be evidence based to select true visually skilled drivers [26]. In the United States, visual acuity requirements are highly variable from state to state ranging from 20/40 to 20/70 in the better eye. Some of the researches done in USA demonstrated that for young and middle aged drivers, there was no association between poor visual acuity and motor vehicle collision involvement. However significant association was observed among older drivers. While not universal, visual field testing is used by many states of USA for licensing purpose and specific visual field requirements are highly variable ranging from 95 degrees to 140 degrees. The authors mentions that a first and large scale sample size population based assessment of visual field impairment and driver safety was conducted by Johnson and Keltner in 1983. The study reported that driver with severe binocular field loss had significant higher motor vehicle collision and violation rates compared to those without any loss. However several other studies have not reported elevated motor vehicle collision rates for those with visual field impairment. Regarding contrast sensitivity, among the published literature, some of the articles states that contrast sensitivity impairment might be associated with motor crash involvement and again a few articles states that it would not be associated with crash involvement. Contrast sensitivity deficiencies are common in older adults with age related cataract. Motor crash or collision risk might be twice as strong when both eyes were impaired in contrast sensitivity compared to when only one eye was impaired. So the cataract surgery and IOL insertion may reduce the risk of crash involvement during driving. Considering binocularity and stereopsis, several studies on commercial drivers have reported that impaired binocularity and stereopsis were at elevated risk for motor vehicle collision. Color vision is tested at license application in over 40 states in America and it should be normal for a commercial vehicle license. Though a color vision deficiency is not a major risk factor for crash involvement, this test is meant to ensure that drivers can obey color traffic control devices and other color signals on the road. Some laboratory and field studies have confirmed that drivers with color vision deficiencies have longer reaction time to traffic control devices with color signals and are likely to make more color confusion than a person with normal color vision. But the literatures largely supports that there is no link between color vision deficiencies and vehicle crash involvement. But the disability glare or increased glare sensitivity particularly among adults could be a serious threat to the safety of older drivers but studies have not scientifically supported this notion [26].

CONCLUSION

Driving a vehicle requires people to have particular levels of static vision and other specific visual functions to be able to operate effectively and safely. Since some of the visual functions might decline with an individual's age, the vision and driving performance of

older drivers should be assessed regularly starting at the age of 65 years. . Every driver involved in a road traffic accident should ideally have reassessment of visual functions by an eye specialist. During eye testing, not only the visual acuity, but other important visual functions like visual field, binocularity, and color vision and contrast sensitivity should be well evaluated. This is a very serious issue and needs immediate societal and legislative attention.

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