Synthesis title:

Eyesight and Driving

Category: Drivers

Other Relevant Topics:

- Fitness to Drive (Drivers)
- Drink Driving (Drivers)
- Drug Driving (Drivers)
- Older Drivers (Drivers)
- Fatigue (Drivers)
- Distraction (Drivers)

Keywords:
Eyesight and Driving, Vision and Driving

About the Road Safety Observatory

The Road Safety Observatory aims to provide free and easy access to independent road safety research and information for anyone working in road safety and for members of the public. It provides summaries and reviews of research on a wide range of road safety issues, along with links to original road safety research reports.

The Road Safety Observatory was created as consultations with relevant parties uncovered a strong demand for easier access to road safety research and information in a format that can be understood by both the public and professionals. This is important for identifying the casualty reduction benefits of different interventions, covering engineering programmes on infrastructure and vehicles, educational material, enforcement and the development of new policy measures.

The Road Safety Observatory was designed and developed by an Independent Programme Board consisting of key road safety organisations, including:

- Department for Transport
- The Royal Society for the Prevention of Accidents (RoSPA)
- Road Safety GB
- Parliamentary Advisory Council for Transport Safety (PACTS)
- RoadSafe
- RAC Foundation

By bringing together many of the key road safety governmental and non-governmental organisations, the Observatory hopes to provide one coherent view of key road safety evidence.

The Observatory originally existed as a standalone website, but is now an information hub on the RoSPA website which we hope makes it easy for anyone to access comprehensive reviews of road safety topics.

All of the research reviews produced for the original Road Safety Observatory were submitted to an Evidence Review Panel (which was independent of the programme Board), which reviewed and approved all the research material before it was published to ensure that the Key Facts, Summaries and Research Findings truly reflected the messages in underlying research, including where there may have been contradictions. The Panel also ensured that the papers were free from bias and independent of Government policies or the policies of the individual organisations on the Programme Board.

The Programme Board is not liable for the content of these reviews. The reviews are intended to be free from bias and independent of Government policies and the policies of the individual organisations on the Programme Board. Therefore, they may not always represent the views of all the individual organisations that comprise the Programme Board.

Please be aware that the Road Safety Observatory is not currently being updated; the research and information you will read throughout this paper has not been updated since 2017. If you have any enquiries about the Road Safety Observatory or road safety in general, please contact **help@rospa.com** or call **0121 248 2000**.

How do I use this paper?

This paper consists of an extensive evidence review of key research and information around a key road safety topic. The paper is split into sections to make it easy to find the level of detail you require. The sections are as follows:

Key Facts	A small number of bullet points providing the key facts about the topic, extracted from the findings of the full research review.
Summary	A short discussion of the key aspects of the topic to be aware of, research findings from the review, and how any pertinent issues can be tackled.
Methodology	A description of how the review was put together, including the dates during which the research was compiled, the search terms used to find relevant research papers, and the selection criteria used.
Key Statistics	A range of the most important figures surrounding the topic.
Research Findings	A large number of summaries of key research findings, split into relevant subtopics.
References	A list of all the research reports on which the review has been based. It includes the title, author(s), date, methodology, objectives and key findings of each report, plus a hyperlink to the report itself on its external website.

The programme board would like to extend its warm thanks and appreciation to the many people who contributed to the development of the project, including the individuals and organisations who participated in the initial consultations in 2010.

Key facts

- Good vision is essential for safe driving and motorcycling. The law sets minimum eyesight standards that drivers and motorcyclists must meet.
- There are no official estimates of the number of drivers and motorcyclists on the road with eyesight that fails to meet the minimum legal standards. However, some studies suggest 2% to 3% of drivers have vision below the minimum legal standards.
- Poor vision is only recorded as a contributory factor in less than 1% of reported road deaths and injuries, although this may be an under-estimate due to the difficulties in assessing whether poor eyesight played a role in accidents.
- In 2011, 5,285 drivers and motorcyclists had their licences revoked because they could not pass a standard eye test, an increase of 8% since 2010.
- There is only weak evidence of a link between poor vision and increased accident risk. However, research establishes how vision defects impair driving, and potentially increase crash risk.
- Eyesight problems become more prevalent as we grow older, and the driving of older people is more likely to be impaired by eyesight problems.
- Field of View Defects have been associated with impaired driving, although the impairment varies between individuals.
- Cataracts cause more significant driving impairment than most other forms of poor vision, but cataract surgery can solve these problems.
- Poor vision causes greater impairment at night. Particular difficulties include the ability to see pedestrians, road signs, hazards in the road and glare from oncoming vehicle headlights.
- Some drivers who pass the driving eyesight test still exhibit impaired driving due to poor eyesight. There are calls for the Number Plate Test to be replaced with a proper assessment of visual acuity performed under controlled conditions.

Summary

- Good vision is essential for safe driving and motorcycling. Therefore, the law sets minimum eyesight standards that drivers and motorcyclists must meet. The standards for lorry and bus drivers are more stringent than for car drivers and motorcyclists.

- There are no official estimates of the number of drivers and motorcyclists on the road with eyesight that fails to meet the minimum legal standards. However, some studies suggest 2% to 3% of drivers have vision below the minimum legal standards.

- In 2011, 5,285 drivers and motorcyclists had their licences revoked because they could not pass a standard eye test, an increase of 8% since 2010.

- In 2016, "uncorrected, defective eyesight" was reported as a contributory factor in 7 reported fatal road accidents, 57 reported serious road accidents, and 193 reported road accidents in total - less than 2% of reported road accidents. (RRCGB, DfT, 2017)

- These accidents resulted in 7 people being killed, 63 being seriously injured and 182 road casualties in total. (RRCGB, DfT, 2017)

- There is only weak evidence of a link between poor vision and increased accident risk. However, research establishes how vision defects impair driving, and potentially increase crash risk.

- There is a wide variation of types of poor vision (for example, cataracts, short or long sightedness, visual field defects) each of which has a different effect on safe driving ability, depending on the circumstances (for example, night-time driving) and the severity of the vision defect.

- Eyesight problems become more prevalent as we grow older, and the driving of older people is more likely to be impaired by eyesight problems.

- Field of View Defects have been associated with impaired driving, although the impairment effects varies between individuals and can be difficult to predict without an on-road driving assessment. Some drivers can compensate for their vision problems by, for example, making more head movements to increase their visual scanning.

- Cataracts cause more significant driving impairment than most other forms of poor vision, especially at night. However, after cataract surgery, driving ability can return to the standard of drivers without vision problems.

- Some drivers wearing prescription spectacles or contact lenses can experience difficulties with tasks requiring changes of focus (such as looking far ahead and then at the dashboard displays).

- Drivers with monocular vision can drive safely, although drivers with bus, coach or lorry licences must inform DVLA about the condition.

- Poor vision causes greater impairment at night. Particular difficulties include the ability to see pedestrians, road signs, hazards in the road and glare from oncoming vehicle headlights.

- These difficulties prompt some drivers to avoid driving in the dark (self-regulation) or to give up driving.

- There is little evidence of the effects of colour vision deficiency on driving. However, one study found some types of colour vision deficiency result in slower response times to traffic lights.

- Many research studies have found that some drivers who pass the driving eyesight test still exhibit impaired driving due to poor eyesight.

- Visual acuity is a poor screening test, and many studies recommend additional tests, such as contrast sensitivity and visual field tests.

- The Optical Confederation believes the Number Plate Test should be replaced with a proper assessment of visual acuity performed under controlled conditions.

- There is also evidence of uncertainty among eye health professionals in deciding which patients should be advised not to drive.

METHODOLOGY

A description of the methodological approach to all of the research reviews on the Road Safety Observatory is available at http://www.roadsafetyobservatory.com/Introduction/Methods. .

This review was compiled during December 2012 to February 2013. In December 2017, statistics from Reported Road Casualties Great Britain were updated to Reported Road Casualties Great Britain 2016.

The steps taken to produce this review are outlined below:

Identification of relevant research

Searches were carried out on pre-defined research (and data) repositories. Search terms used to identify relevant papers included but were not limited to:

- Eyesight and Driving
- Vision and driving

A total of 77 pieces of potentially relevant research were identified.

Initial review of research

This primarily involved sorting the research items based on key criteria, to ensure the most relevant and effective items went forward for inclusion in this review. Key criteria included:

- Relevance: whether the research makes a valuable contribution to this synthesis, for example robust findings from a hospital-based study.
- Provenance: whether the research is relevant to drivers, road safety policies or road safety professionals in the UK. If the research did not originate in the UK the author and expert reviewer have applied a sense check to ensure that findings are potentially relevant and transferable to the UK.
- Age: Priority is given to the most up to date titles in the event of over-lap or contradiction, although older research papers are included because much of the fundamental research took place as seat belts were being developed and used.
- Effectiveness: whether the research credibly proves (or disproves) the effectiveness of a particular road safety initiative or intervention.

Following the initial review, 35 pieces of research were taken forward to form the basis for this synthesis, 9 of which were published in the UK.

Detailed review of research

Seven medical conditions are reviewed based on the availability of evidence pertaining to road crash risk: vision; hearing impairments; sleep disorders; cardiovascular disease; musculoskeletal impairments; epilepsy, and diabetes. Key facts, figures and findings were extracted from the identified research to highlight pertinent road safety issues and interventions. A high proportion of the research used in this review derives from outside of the UK, but has been included because it is relevant to UK road safety.

KEY STATISTICS

Most of the information drivers and riders gather is visual, and so good vision is essential for safe driving and motorcycling. Drivers and motorcyclists must be able to see other road users, signs, markings, traffic lights, obstacles and hazards ahead (and behind, using their mirrors) and in their peripheral vision. They must be able to estimate distance and movement in order to make appropriate decisions about their own actions (eg, slow down, steer, stop, accelerate, etc).

Therefore, the law sets minimum eyesight standards that drivers and motorcyclists must meet. The UK's driver licensing rules are based on the Second and Third European Directives on Driving Licences (91/439/EEC and 2006/126/EC).

In the UK, car drivers and motorcyclists must:

- be able to read (with glasses or contact lenses, if necessary) a car number plate made after 1 September 2001 from 20 metres
- have a visual acuity (with glasses or contact lenses, if necessary) of at least decimal 0.5 (6/12) measured on the Snellen scale using both eyes or, if they have sight in one eye only, in that eye.
- have an adequate field of vision - the area you can see when looking straight ahead

Only where there is reason to doubt that a person's vision is adequate, are they required to be examined by a competent medical authority, If a person has any doubt about whether they can meet the standard, they should get advice from a GP, optician or eye specialist.

The medical licensing standards for lorry and bus drivers are more stringent than for car drivers. They must have a visual acuity, with corrective lenses if necessary, of at least Snellen 6/7.5 (decimal 0.8) in the better eye and at least Snellen 6/12 (decimal 0.5) in the worse eye.

When corrective lenses are used to attain a minimum acuity of 6/7.5 (decimal 0.8) and 6/12 (decimal 0.5), either:

a) the uncorrected acuity in each eye must reach Snellen 3/60 (decimal 0.05); or
b) the corrected minimum acuity must be achieved by means of glasses with a power not exceeding plus or minus eight dioptres (unit of measurement of optical power of a lens) or with the aid of contact lenses. The glasses or contact lenses must be well tolerated ("the spectacles requirement").

Drivers and motorcyclists who need to wear glasses or contact lenses to meet the standards must wear them every time they drive or ride. Full details of the eyesight requirements for drivers in the UK are available at https://www.gov.uk/driving-eyesight-rules.

Drivers and motorcyclists must report any eyesight problem that affects both eyes, or the remaining eye if they only have one eye, to the DVLA. A list of the disorders that must be reported in contained in the Visual Disorders section of the DVLA's "At a Glance Guide to the Current Medical Standards for Fitness to Drive", available at http://www.dft.gov.uk/dvla/medical/aag/Chapterview/Visual%20Disorders.aspx , A driver may have their licence refused or revoked if the DVLA considers they are a likely source of danger to the public when driving because their eyesight is below the EU minimum standard. Drivers and motorcyclists can be fined up to £1,000 if they do not tell DVLA about a medical condition, including eyesight problems, that affects their driving. Short sight, long sight, colour blindness, or surgery to correct short sightedness does not need to be reported provided the driver can meet the eyesight standards.

Many of these eyesight disorders can be symptoms of other diseases, such as diabetes, and in any case become more common as people grow older.

Estimates of drivers with illegal vision

There are no official estimates of the number of drivers and motorcyclists on the road with eyesight that fails to meet the minimum legal standards. There have been many surveys, typically conducted by insurance companies or eyecare companies; for example a Specsavers survey estimated that as many as 3.5m people could be driving with eyesight below the legal minimum, and that 22% of British drivers who need glasses or contact lenses have knowingly driven without them. (Specsavers, undated). However, there is little hard evidence of the number of drivers and motorcyclists with eyesight that fails to meet the minimum legal standards.

A cost-benefit analysis of the case for stricter eye tests identified two studies of the prevalence of UK drivers with poor eyesight. The first was a 1980 study in which 1,368 drivers were assessed at 25 sites (mainly garage forecourts) across the UK in 1976. It found that 3.1% of drivers had a visual acuity of 6/12 or lower, with 1.1% of drivers having a visual acuity below 6/12 (the minimum legal standard for driving). The proportion of drivers with low visual acuity increased with age, peaking at 5% in the 65-69 year age group. (RSA Insurance Group, 2012)

The second study gave details of a 2007 survey and eyesight test amongst a random sample of 298 drivers and motorcyclists stopped under police supervision on a single carriageway road in South Wales. The eyesight test replicated the number plate test used in the UK driving test. Five of these drivers failed to meet the legal vision standard for driving. The failure rate was greater among drivers older than 40 years of age with 2.2% failing the number plate test in that age group. The report suggested that if this proportion held true for all drivers and motorcyclists, 26,776 drivers in Wales and over half a million drivers in the UK would be on the road with illegal eyesight. (Anuradha et al, 2007)

The cost-benefit analysis also found a study conducted by a motor insurance company that could not be verified, but found that one in six drivers randomly stopped on the M25 failed to pass the standard number plate test. It also reported surveys in other countries that found between 2% to 6% of drivers had poor vision. (RSA Insurance Group, 2012)

In a submission to a House of Commons Transport Committee's Inquiry, the Optical Confederation quoted a 2009 RNIB report that estimated that 1.8 million people in the UK have vision below the driving standard of 6/12 (which does not include those with visual field problems), and that this will increase to 4 million by 2050. (Optical Federation, 2011) However, these are not estimates of the numbers of drivers with poor vision.

Using estimates from the 2009 RNIB study of the proportion of the population with visual acuity below 0.5, but not legally blind, and the numbers of licensed drivers, the RSA cost-benefit analysis estimated that 2.4% of drivers have poor vision. Based on the proportion of accidents in 2010 (0.2%) in which poor vision was recorded as a contributory factor, they calculated that in 2010 these drivers were involved in 2,048 road accidents, causing 2,874 casualties, due to their poor vision. (RSA Insurance Group, 2012)

In 2011, DVLA statistics show that 5,285 drivers and motorcyclists had their licences revoked because they could not pass a standard eye test, an increase of 8% since 2010. (email communication with the DVLA,2013)

Road Accidents and Casualties Caused by Poor Vision

Vision is not routinely tested when road crashes occur and so reported road casualty statistics are not able to provide details of whether any of the drivers and riders involved had vision below the legal minimum standards. However, the contributory factors system, in which a police officer attending the accident scene makes a subjective assessment of the factors that might have contributed to the accident, provides some estimates.

It is very difficult to obtain reliable estimates of crash risk, or number of crashes, involving drivers who have, or were impaired by, poor vision because road accident data does not normally include information about the medical status of those involved, and indeed it would be very difficult for it to do so.

In 2015, "uncorrected, defective eyesight" was reported as a contributory factor in 10 reported fatal road accidents, 48 reported serious road accidents, and 233 reported road accidents in total - less than 2% of reported road accidents. These accidents resulted in 10 people being killed, 54 being seriously injured and 347 road casualties in total. Contributory factors are largely subjective, reflecting the opinion of the reporting police officer, and are not necessarily the result of extensive investigation. They are not necessarily the result of extensive investigation, and subsequent enquiries could lead to the reporting officer changing his/her opinion. (RRCGB, DfT, 2016)

Table 1: Contributory Factors in Reported Road Accidents, Great Britain, 2015

	Fatal	**Serious**	**Slight**	**Total**
Uncorrected, defective eyesight	10 (1%)	48 (0%)	174 (0%)	233 (0%)

Table 2: Contributory Factors in Reported Road Casualties, Great Britain, 2015

	Fatal	**Serious**	**Slight**	**Total**
Uncorrected, defective eyesight	10 (1%)	54 (0%)	281 (0%)	347 (0%)

Health professionals play a key role in mitigating health-related impairment and so reducing the risk of crashes, while enabling as many people as possible to stay safely mobile. There are many options for address fitness to drive problems:

- Self-regulation (for example, drivers compensate for the impairment by changing when, where and how they drive, such as not driving at night)
- Restricted licenses (for example, a licence being valid for only three years; in some countries, the driver is not permitted to drive in certain situations, such as at night)
- Medical treatment to address the cause of the problem (for example, medication, surgery or simply using spectacles or contact lenses).
- Stopping driving, either for a temporary period or permanently
- Driver rehabilitation training to help the driver cope with the impairment
- Driver education to help the driver understand the effect of the impairment
- Vehicle adaptation (for example, modified controls to enable the driver to drive with their impairment)

Effects of Vision Defects on Driving

A 2002 review of previous research on vision and driving found that evidence linking poor vision and crash rates was “equivocal”. It identified research in the 1960s and 1970s that found drivers with poor vision had higher crash rates than those with good vision, but also research that found only weak evidence for this. (Wood, 2002)

Another 2002 review, conducted in the UK, concluded that there was only very weak correlations between poor vision and crash risk for drivers under 54 years old, and only weak correlations for over 55 year olds. Even when an association between eyesight and accidents was found, this did not prove that poor vision was a causal factor in the accidents. (DfT, 2002)

A 2010 literature review also concluded that many studies have indicated that visual acuity is, at best, very weakly linked to crash risk and so is a poor screening test for identifying drivers who are at-risk. This is because while visual acuity driving skills (such as the ability to recognise road signs) are needed for driving, they may not be crucial to avoiding collisions. It may also be because visual acuity tests were not designed to assess safe driving skills. (Owsley and McGwin, 2010)

Despite the weak evidence of the number of road accidents and casualties caused by drivers or riders with defective vision, or the increased crash risk attributed to poor vision, there is a strong body of research that establishes how vision defects impair driving, and potentially increase crash risk.
There is a wide variation of types of poor vision (for example, cataracts, short or long sightedness, visual field defects) each of which has a different effect on safe driving ability, depending on the circumstances (for example, night-time driving) and the severity of the vision defect.

Age and Vision

However, research shows that the driving of older people is more likely to be impaired by eyesight problems. A 2009 study in which 20 young and 19 older drivers drove around a closed-road circuit with their normal vision and with simulated cataracts and simulated blurred vision found that the simulated vision problems caused greater impairment to the older drivers. It reduced the number of road signs they were able to read, slowed their performance on the course and reduced their ability to cope with distractions The older drivers also commented that they often felt uncomfortable when taking their eyes off the road to look at a visual display (numbers on a dashboard monitor that tested their ability to multi-task), especially under the cataract condition. (Wood et al, 2009)

A review of the evidence about the changes in visual function due to aging found that visual impairment becomes significantly more prevalent with increasing age because of the normal aging process and an increased likelihood of eye disease. It also noted research that older drivers are more restricted in their head movements, which can limit their overall field of view. (Wood, 2002)

However, the review found limited information about which specific aspects of driving deteriorate with age, how ‘unsafe’ elderly drivers should be identified and assessed, how and why they self-regulate their driving and how they cope with the loss of their driver licence. (Wood, 2002)

Types of Vision Problems

Field of View Defects

The Useful Field of View (UFOV) is the visual field over which a person can acquire information in a brief glance without head or eye movements. A meta-analysis of eight studies found that poorer UFOV was associated with negative driving outcomes. Of the visual conditions considered, UFOV was most strongly correlated with at-fault crashes, whereas visual acuity and contrast sensitivity tests were only modestly correlated with at-fault crashes. This evidence across numerous studies using different methodologies confirms the importance of the UFOV assessment as a valid and reliable index of driving performance and safety. (Clay et al, 2005)

In a 2012 Australian study, 92 drivers, aged 65-88 years, completed the UFOV test including an assessment of visual processing speed, divided attention, and selective attention, and a driving assessment on a closed-road circuit. UFOV significantly predicted driving performance. Participants who rated as safe on the UFOV performed significantly better in terms of overall driving performance and also experienced less interference from distracters. (Wood et al, 2012)

Older adults who were rated as higher risk on the UFOV, particularly on the selective attention subtest, demonstrated the poorest driving performance in the presence of distracters. This finding suggests that the selective attention subtest of the UFOV may be more effective in predicting driving difficulties in situations of divided attention. (Wood et al, 2012)

A review of 1,350 patients between 1976 and 2004 identified 131 patients with visual field loss who had taken an on-road driving assessment. Some were rated as “safe” during on-road driving assessments. Patients with larger visual field loss were more likely to have been rated as ‘unsafe’ drivers than those with smaller visual field loss. (Racette and Casson, 2005)

The study concluded that it is difficult to predict whether a patient with a visual field defect will be able to drive safely based on the extent and location of the deficit. Although the nature of the visual field loss may be related to driving performance, large individual differences exist, which highlights the need for individual on-road assessments for patients with visual field defects. It should be noted that these drivers were not compared with drivers who had good vision. (Racette and Casson, 2005)

A 2002 study assessed the driving of 87 drivers with visual field defects on a driving simulator and during an on-road driving test. Drivers with visual field defects showed poorer performance with driving speed, steering stability, lateral position, time to collision, and time-headway. They tended to compensate for their vision problems by reducing speed (in cases of central visual field defects) and increasing scanning (in cases of peripheral visual field defects). Driving examiners considered reduced speed and increased scanning to be valid compensation for central and peripheral visual field defects, respectively. (Coeckelbergh et al, 2002)

Hemianopia and Quadrantanopia

Hemianopia and Quadrantanopia is decreased vision in half or quarter of the visual field of one or both eyes, most commonly caused by stroke, brain tumour, and trauma. Some research suggests that some drivers with these conditions are able to compensate sufficiently to be rated as ‘safe’ to drive.

A questionnaire survey of 17 drivers with hemianopic field loss, 7 with quadrantanopic loss, and 24 age-matched controls with normal visual fields, found that drivers with hemianopic and quadrantanopic field loss expressed significantly more difficulty with driving manoeuvres involving peripheral vision and independent mobility, compared to those with normal visual fields. (Parker et al, 2011)

However, some drivers with hemianopia or quadrantanopia viewed themselves as safe drivers when in fact their driving performance was judged unsafe by a driving professional. In an on-road driving assessment in which their driving was evaluated by a certified driving rehabilitation specialist, drivers with hemianopia and quadrantanopia who were rated as unsafe to drive were no more likely to report driving difficulty than those rated as safe. (Parker et al, 2011)

In a 2011 study, 22 participants (with a current licence or seeking to resume driving) with hemianopic defects and 8 with quadrantanopic defects (mean age, 53 years) and 30 with normal vision (mean age, 53 years) drove a 6.3-mile route along non-interstate city roads under normal traffic conditions. As a group, drivers with hemianopic or quadrantanopic defects drove slower, exhibited less excessive cornering or acceleration, and executed more shoulder movements than the control group drivers. (Wood et al, 2011)

Those drivers with hemianopic or quadrantanopic defects who were rated as safe made more head movements into their blind field and more eye movements than those who were rated unsafe. They also kept a more stable lane position, exhibited less sudden braking and drove faster than those rated unsafe. Future research should evaluate whether these characteristics could be trained in rehabilitation programs designed to improve driving safety in this population. (Wood et al, 2011)

In a USA study, an occupational therapist evaluated 31 male and 29 female drivers, aged 33 to 73 years in normal on-road driving; 22 of them had hemianopia, 8 had quadrantanopia, and 30 had normal vision. Scores for visual processing speed and attentional skills were worse in those with hemianopia compared with those with normal visual fields. (Elgin et al, 2010)

The percentage of drivers with hemianopia exhibiting problems was greater than for those with normal visual fields. For example, 40.9% (9 out of 22) of drivers with hemianopia exhibited difficulty with vehicle control skills, 36.3% (8 out of 22) with adjustment to traffic speed conditions, 27.2% (6 out of 22) with reaction to unexpected events and 27.2% (6 out of 7) performed unusually bad driving manoeuvres. The corresponding percentages for drivers with normal visual fields were 6.7%, 6.7%, 0%, and 0%, (2 out of 30 and 0 out of 30) respectively. (Elgin et al, 2010)

On the non-interstate roads, all drivers with normal visual fields were judged to have the potential for safe driving, whereas only 87.5% (7 out of 8) of drivers with quadrantanopia and 77% (17 out of 22) of the drivers with hemianopia were judged to have the potential for safe driving. (Elgin et al, 2010)

On interstate roads (some of the drivers were not evaluated because they preferred not to drive on those roads or were not permitted to do so) all except 1 of the drivers with normal visual fields were judged to have the potential for safe driving. Most of the drivers with hemianopia or quadrantanopia (77.3%, 20 out of 22), 87.5% (7 out of 8) respectively) were judged to have the potential for safe driving. (Elgin et al, 2010)

The authors conclude that some people with these conditions can demonstrate they are fit to drive in an on-road evaluation by an occupational therapist who specialises in driving. They suggest that drivers with better contrast sensitivity and average light sensitivity in the remaining areas of visual field and those with faster processing speeds were more likely to be judged as safe drivers. (Elgin et al, 2010)

Cataracts

Cataracts cause a clouding of the eye lens which reduces vision, and are the most common cause of blindness. They also cause more significant impairment to driving ability than most other forms of poor vision.

In a 2012 Australian study, 28 young adults (aged 20 to 36 years) drove a closed road course at night, with their normal vision, and with simulated blurred vision and simulated cataracts. Pairs of headlamps were used to simulate oncoming traffic and pedestrians wearing black clothes, black clothes with a retro-reflective shoulder belt or black clothes with retro-reflective tape around the waist, elbows, ankles, knees and shoulders, were placed at separate locations. (Wood et al, 2012)

Blurred vision (commonly caused by not wearing the correct spectacles or contact lenses) and simulated cataracts both reduced drivers' ability to recognise pedestrians at night. The simulated cataracts were significantly more disruptive than simulated blurred vision. Drivers with normal vision responded to pedestrians at 3.6 times longer distances than with the simulated blurred vision, and at 5.5 times longer distances than with the simulated cataracts. (Wood et al, 2012)

Drivers with simulated blurred vision responded to 42% of the pedestrians when there was no headlight glare, but only 6% when there was glare. None of the drivers with simulated cataracts responded to the pedestrians in black clothing. However, simulated cataracts and blurred vision cause an immediate deterioration in eyesight, whereas real ones develop over a number of years. Therefore, the effect may have been worse for these drivers as they had little or no time to adjust to their change in vision ability. (Wood et al, 2012)

In another study, 186 drivers (121 females and 65 males, aged 17 to 59 years old) with normal vision completed a validated video-based hazard perception driving test wearing either mild or moderate cataract simulation goggles, or goggle frames without lenses (ie, the control group with normal vision). Those wearing moderate simulated cataract goggles were significantly slower than the control group in both the hazard perception test, and in a hazard change detection task. Those with the mild simulated cataract goggles were slower than the control group in the hazard change detection task, but not the hazard perception test. The results may also have been affected by the fact that in real-life cataracts develop over a long period of time, whereas the simulated cataracts create an immediate change. (Marrington et al, 2008)

However, cataracts do not necessarily mean that drivers need to lose their driving licence permanently because cataracts can be surgically removed. In a study to investigate whether cataract surgery can improve driving performance, 29 older patients, aged 50 to 89 years, with bilateral cataracts who were scheduled for cataract surgery and 18 drivers with normal vision were tested. Driving and vision performance were measured before cataract surgery and after second eye surgery for the patients with cataracts and on two separate occasions for the control groups. Driving performance was assessed on a closed-road circuit, with vision tests being conducted at the same session. (Wood et al, 2006)

Patients with cataracts had significantly poorer driving performance at the first visit than the control group with normal vision, over a range of driving measures. However, their driving performance significantly improved to the level of the control group after the extraction of both cataracts. The improvement in overall driving after cataract surgery was best predicted by the change in contrast sensitivity in the second operated or better eye. (Wood et al, 2006)

Bilateral cataract surgery resulted in marked improvements in sign recognition, ability to detect and avoid hazards, and overall driving score. The authors noted that this was consistent with previous research (Wood and Carberry, 2004) and that self-reported data suggests that cataract surgery improves many aspects of driving with 25% of patients with cataracts who had ceased to drive before surgery resuming driving afterwards. (Wood et al, 2006)

Presbyopia (Difficulty in focussing at short distances)
Drivers with short sight usually need to wear prescription spectacles or contact lenses, and the effect of the type of vision correction on driving performance can vary. A questionnaire survey sent to 1,350 Optometry clinics in Australia resulted in 324 responses (24%), but only 255 (19%) were suitable for analysis. The respondents (mean age 55 years) were categorised into five age-matched groups: 50 wore no vision correction for driving, 54 used bifocal spectacles, 50 wore progressive spectacles, 53 used monovision contact lenses and 48 used multifocal contact lenses. (Chu et al, 2009)

Overall, these drivers expressed high ratings of satisfaction with all types of vision correction during daytime driving. However, multifocal contact lens wearers were significantly less satisfied with aspects of their vision at night than in the day, especially with disturbances from glare and haloes. Progressive spectacle wearers noticed more distortion of peripheral vision, whereas bifocal spectacle wearers reported more difficulties with tasks requiring changes of focus (such as looking far ahead and then at the dashboard displays). Those who wore no optical correction for driving reported problems with intermediate and near tasks. (Chu et al, 2009)

The authors concluded that subjective visual experiences of different presbyopic vision corrections when driving vary depending on the vision tasks and lighting level, and that eye-care practitioners should be aware of the driving-related difficulties experienced with each vision correction type and the need to select corrective types that match the driving needs of their patients. (Chu et al, 2009)

A study in which 11 drivers aged 51 to 63 years (5 females and 6 males) with presbyopia, drove at night on a closed-road circuit while wearing each of four vision corrections (single-vision distance spectacles, progressive-addition spectacles, monovision contact lenses, and multifocal contact lenses) assessed the effects of each type of vision correction on their low-contrast road hazard detection and avoidance, road sign and near target recognition, lane-keeping, driving time, and distance at which they could recognise street signs. (Chu et al, 2010)

The study found that night-time driving was significantly affected by the use of different types of presbyopic vision correction. Multifocal contact lenses negatively affected more of the driving performance measures, and spectacles performed better than the contact lenses. Single vision distance lens wearers showed significant loss of performance for recognition of near targets, such as the radio and speedometer. (Chu et al, 2010)

Wearing multifocal contact lenses resulted in significantly slower driving speeds than wearing progressive-addition spectacles, presumably as a result of poorer overall vision leading to more cautious driving. Multifocal contact lenses increased the likelihood of hitting a low-contrast object on the road, with the difference approaching statistical significance. The mean distance to read a street sign was approximately 60m with single vision distance lens and progressive-addition spectacles, 48m with monovision contact lenses and 38m with multifocal contact lenses. (Chu et al, 2010)

There were no significant differences between the types of vision correction and the number of road signs correctly recognised (61% - 64%) However, when text signs (not speed limit signs) were correctly recognised, monovision and multi-focal contact lenses resulted in significantly longer fixation durations. The distance at which a standard street sign was recognised varied between types of vision correction, in that they were recognised at significantly longer distances with single-vision distance lenses, progressive-addition spectacle lenses and monovision contact lenses, than with multifocal contact lenses. (Chu et al, 2010)

Myopia

Myopia or nearsightedness is a vision condition in which close objects are seen clearly, but objects farther away appear blurred. It is a very common condition but for most people it can easily be corrected with spectacles, contact lenses or laser eye surgery. Drivers who need to wear spectacles or contact lenses to meet the minimum eyesight standards for driving must wear them whenever they drive.

There is some evidence that drivers with night myopia (an increase in near-sightedness in lower light levels) are more likely to be involved in night-time accidents. [Cohen et al, 2007] Another study, using self-report questionnaires from 4,448 drivers of all ages who had been involved in an automobile collision, identified myopia as one of the significant health risk factors (OR = 1.22). (Saberg, 2006)

A comprehensive USA review of health conditions and driving found that night myopia is relatively commonly in young myopic patients. Approximately 38% of young patients (aged 16-25 years) were deemed to have night myopia, with 4% having night myopia of 2.50 diopters. Night myopic lenses are not always effective, which may warrant restrictions in nighttime driving for those individuals without corrective lenses. (Dobbs, 2005)

It has been suggested in the USA that graduated driver licensing programmes may be a possible way of dealing with the prevalence of night myopia among younger drivers by imposing restrictions in nighttime driving for affected drivers. (White et al, 2000)

A study that compared pre-operative and post-operative changes in simulated night driving performance after two types of laser eye surgery to treat moderate myopia using a night driving simulator (NDS) testing from 2 clinical trials. 38 patients had one type of laser surgery and 21 patients had another type. They were relatively young, with none being older than 51 years. The authors concluded that wavefront-guided LASIK to correct myopia combined with a femtosecond laser flap significantly improved mean night driving visual performance and was significantly better than cLASIK using a mechanical keratome. (Schallorn et al, 2009)

Another study, involving 43 eyes implanted with a particular type of contact lens and 45 eyes that had received conventional laser surgery, compared changes in simulated night driving performance after lens implantation or laser eye surgery to correct moderate to high myopic astigmatism. 27 eyes of 14 lens patients and 41 eyes of 21 laser patients underwent a simulated night driving test to assess the detection and identification distances of road signs and hazards with a night driving simulator with and without a glare source before and 6 months after each procedure. (Schallorn et al, 2010)

No significant difference was noted in the pre- to post-operative detection distances with and without the glare source between the two groups. The differences in identification distances without glare were significantly better for business and traffic road signs and pedestrian hazards in the lens group relative to the laser group whereas with glare, only the pedestrian hazards were significantly better. A clinically relevant change of night driving simulator performance was significantly better in the lens group (with and without glare) for all identification tasks. The authors concluded that the lens performed better than conventional laser surgery in the pre- to postoperative night driving simulator. (Schallorn et al, 2010)

Hyperopia

Hyperopia or far-sightedness is a vision condition in which distant objects are usually seen clearly, but close ones do not come into focus. A wide variety of tasks rely on distance vision, including driving. However, there seems to be very little research about the effects of hyperopia on driving.

Monocular Vision

Drivers with monocular vision can drive safely. The main concern with monocular drivers has been their ability to perceive depth, however, depth can be estimated through different cues and its perception does not pose a significant problem when driving. (Racette and Casson, 2005)

The 2002 review of research into vision and driving found some early studies that suggested that drivers with monocular vision had higher crash rates, but more recent ones that found monocular vision did not affect driving performance. (Wood 2002)

A comparison of the visual and driving performance of 40 monocular and 40 binocular truck drivers found that the mononuclear drivers were significantly deficient in contrast sensitivity, visual acuity in low light levels and glare, and binocular depth perception. They were not significantly deficient in static or dynamic visual acuity, visual field of individual eyes, or glare recovery. There was no difference in visual search, lane keeping, clearance judgment, gap judgment, hazard detection, and information recognition between monocular and binocular drivers. (McKnight et al, 1991)

However, monocular drives were poorer than binocular drivers in contrast sensitivity, depth perception, minimal illumination for night vision and glare resistance. This meant that the distance at which the drivers could read signs in the day and at night was much shorter for monocular drivers than the binocular ones. However, overall, the study concluded that monocular drivers have some significant reductions in certain visual capabilities in some driving functions that depended on these abilities, compared with binocular drivers. However, they are not significantly worse than binocular drivers in most driving functions. (McKnight et al, 1991)

An early (1983) study which involved visual field screening of 10,000 volunteers found that drivers with monocular visual field loss had accident and conviction rates equivalent to those of a control group with normal vision. (Johnson and Keltner, 1983)

Night Driving

Several studies have found that poor vision has a greater impairment effect on safe driving at night. Particular difficulties include the ability to see pedestrians, road signs, hazards in the road and glare from oncoming vehicle headlights. (Wood et al 2012, Wood et al 2010, Wood and Owens 2005, and Chu et al 2010).

- There are indications that vision difficulties when driving at night prompt some drivers to avoid driving in the dark (self-regulation) or to give up driving. A questionnaire survey of 900 older (mean age 75 years) people in California found that respondents, especially men, with some types of poor vision were more likely to avoid driving at night, and more likely to decide to stop driving altogether. However, a higher percentage of men than women continued to drive at night with poor vision. (Brabyn et al, 2005)

Colour Vision

People with colour vision deficiency are unable to see colours clearly and accurately, and may find it difficult to distinguish between different colours. Although often called colour blindness, true colour blindness, where no colour can be seen at all, is rare. (NHS Choices website, no date)

There are two main types of colour vision deficiency:

- red-green deficiency – where people are unable to distinguish certain shades of red and green; it is the most commonly inherited type
- blue-yellow deficiency – is a rare condition where it is difficult to distinguish between blue and green, and yellow may appear as a pale grey or purple

Most people with colour vision deficiency learn to adapt to their condition, and it is usually possible to find ways to compensate for difficulty with colours. For example, it is possible to recognise the position of the lights on a traffic light, rather than the different colours. (NHS Choices website, no date)

Globally, colour deficiency affects approximately 1 in 12 men (8%) and 1 in 200 women. In Britain, this means that there are approximately 2.7 million colour blind people (about 4.5% of the entire population), most of whom are male. (colourblindawareness.org, no date)

There is little evidence of the effects of colour vision deficiency on driving, which is not surprising given that colour vision is not recorded on crash records. It found that an early study of a sample of 298 bus drivers, found no relationship between colour deficiency and increased crash rates, while another study reported that the prevalence of defective colour vision was almost twice as great in a sample of 'crash involved' drivers as in their control group although the choice of control group was criticised. (Wood, 2002 and Dobbs, 20050

A 2003 study investigated the effect of colour-vision deficiency by measuring the reaction times and accuracy of identification of traffic light signals of 20 colour-normal and 49 colour-deficient male drivers to the colour of simulated traffic light signals that were presented (at random intervals) against a white background. The mean response times for the colour normal drivers were 525, 410, and 450 milliseconds for red, yellow, and green lights, respectively.

The response times to red lights of drivers with colour deficiency were 35% to 53% longer, with the response time increasing as the severity of the colour deficiency increased. A similar pattern occurred for yellow lights, with increased times between 53% and 85% respectively. The response times to green lights were similar to those of drivers with normal colour vision. Error rates showed patterns similar to those of response times. (Atchison et al, 2003)

How Effective

The Eyesight Test

The main methods of assessing whether a driver's vision meets accepted safety standards, and of preventing those drivers whose vision fails to meet these standards from driving are the minimum legal eyesight standards and the eyesight test in the Driving Test. The UK eyesight standards and test are described above.

However, many of the research studies have found that some drivers who pass the vision test still exhibit impaired driving due to poor eyesight. For example, drivers' ability to see and respond to pedestrians at night was degraded by modest but common visual impairments, even when their visual acuity met the standard for driver licensing. (Chu et al, 2010) Moderate levels of simulated cataract slowed drivers' ability to detect and anticipate traffic hazards, despite the fact that their vision still complied with the minimum legal standard required for driving. (Marrington, 2008)

The 2010 literature review of the role of vision in driving identified many studies indicating that visual acuity is very weakly linked to crash risk and is a poor screening test for identifying drivers who are at-risk. However, it reasoned that visual acuity is related to certain aspects of driving performance (e.g., road sign recognition) and licensing authorities are unlikely to give up visual acuity screening tests. (Owsley and McGwin, 2010)

The authors suggested that a more practical approach to improving the efficacy of vision screening is to examine how current tests could be supplemented by other types of screening approaches, like contrast sensitivity, visual field, processing speed, and divided attention tests, some of which have a large evidence-basis for their relevance to driver safety. (Owsley and McGwin, 2010)

The Optical Confederation in the UK (a coalition of Opticians, Contact Lens Manufacturers, Optometrists, Manufacturing Opticians, and Ophthalmists) believe that the Number Plate Test is an unfair and unreliable test of visual acuity, and is not comparable to the Snellen standards required by the EU Directive or by the UK law. They are also concerned about the variability of the Test caused by differing lighting and weather conditions or by the examiner's estimate of 20 metres. The Optical Confederation, therefore, believes that the Number Plate test should be replaced with a proper assessment of visual acuity performed under controlled conditions. (Optical Federation, 2011)

Several studies suggest that incorporating a Useful Field of Vision test would make the driver's eyesight test more effective at identifying drivers whose vision is not good enough for driving. A meta-analysis of eight studies that reported relationships between UFOV and driving performance concluded that the evidence confirms that the UFOV assessment is a valid and reliable index of driving and safety. (Clay et al, 2005)

An Australian study of older drivers who were rated as higher risk on the UFOV test, suggested that the selective attention subtest of the UFOV may be more effective in predicting driving difficulties in situations of divided attention. (Wood et al, 2012) A 2002 Australian study concluded that motion sensitivity and the UFOV tests significantly improve the predictive power of vision tests for driving performance. It added that although such measures may not be practical for widespread screening, their application in selected cases should be considered.

A UK study compared the results of the Snellen test with those of the number plate test for 100 Ophthalmology outpatients with 6/9 vision or 6/12 vision. It found that 26% of patients with 6/9 vision failed the number plate test, but 34% of patients with 6/12 vision passed the number plate test. (Currie et al, 2000)

It also found uncertainty among eye health professionals in deciding which patients should be advised not to drive. 76% of GPs advised patients with 6/9 vision that they could drive, 13% said they should not drive, and 11% were unsure. 21% said patients with 6/12 vision could drive, 54% said they should not drive, and 25% were unsure. (Currie et al, 2000)

The level of acuity at which optometrists, opticians, and ophthalmologists would advise drivers against driving ranged from $6/9^{-2}$ (ability to read all except two letters on the 6/9 line of the Snellen chart) to less than 6/18. The report concluded that Snellen acuity is a poor predictor of an individual's ability to meet the required visual standard for driving. (Currie et al, 2000)

Individual Driving Assessments

Several studies suggest that their findings of the problems caused by vision impairments, and ways of compensating for some of these (for example, head movements) should be used to inform driver training programmes. (Wood et al 2011, Parker et al 2011, Owsley and McGwin 2010, Elgin et al 2010)

A review of 131 patients with visual field loss who had taken an on-road driving assessment showed that some with visual field loss were rated as “safe” during on-road driving assessments, and that it is difficult to predict whether a patient with a visual field defect will be able to drive safely based on the extent and location of the deficit. It highlighted the need for individual on-road assessments for patients with visual field defects. (Racette and Casson, 2005)

Driver Adaptations

Research also shows that drivers make adaptations to compensate for their impaired vision, most typically by wearing corrective spectacles or contact lenses (although the effects of these vary as discussed above), by making more head and shoulder movements, by avoiding driving at night and ultimately by stopping driving altogether. Also, as discussed above, cataract surgery is effective at returning a driver’s vision, and their driving, to the standard of drivers with good vision.

Analysis of data from a cohort study of 2,520 older adults followed over 8 years with data collected every two years indicated that older drivers who achieved worse scores at the start of the study in visual acuity, contrast sensitivity, and central or lower peripheral visual fields were more likely to stop driving. Those who experienced 2-year losses in acuity, contrast sensitivity, or lower peripheral visual fields were more likely to stop driving. (Freeman et al, 2005)

Other Approaches

One study suggested that there are possible consequences for road design and that creating high contrast driving environments may improve hazard detection for those with poor contrast sensitivity. (Marrington et al, 2008)

References

Title:	**Contributory Factors to Reported Road Accidents 2012**
Author:	Department for Transport
Published:	Department for Transport,2013 (in Reported Road Casualties Great Britain 2012)
Link:	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/269601/rrcgb-2012-complete.pdf
Objectives:	To provide insight into why and how road accidents occur.
Methodology:	Analysis of contributory factors assigned to reported road accidents by police officers attending the accident scenes.

Key Findings:

- In 2012, "Uncorrected, defective eyesight" was reported as a contributory factor in:

  6 (less than 1%) of reported fatal road accidents
  59 (less than 1%) of reported serious road accidents
  186 (less than 1%) of reported slight road accidents
  251(less than 1%) of reported all reported road accidents

- "Uncorrected, defective eyesight" was reported as a contributory factor in:

  9 (less than 1%) of reported fatal road casualties
  65 (less than 1%) of reported serious road casualties
  279 (less than 1%) of reported slight road casualties
  350 (less than 1%) of reported all reported road casualties

- Contributory factors are largely subjective, reflecting the opinion of the reporting police officer, and are not necessarily the result of extensive investigation. Some factors are less likely to be recorded. Subsequent enquiries could lead to the reporting officer changing his/her opinion.
- The contributory factors are different from the remainder of the STATS19 data which is based on the reporting of factual information. While this information is valuable in helping to identify ways of improving safety, care should be taken in its interpretation.

Format: Pdf	Cost: Free
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Reported Road Casualties Great Britain 2013**
Author:	Department for Transport
Published:	Department for Transport,2014
Link:	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/359311/rrcgb-2013.pdf
Objectives:	To provide insight into why and how road accidents occur.
Methodology:	Analysis of contributory factors assigned to reported road accidents by police officers attending the accident scenes.

Key Findings:

- In 2013, "Uncorrected, defective eyesight" was reported as a contributory factor in:

  9 (less than 1%) of reported fatal road accidents
  51 (less than 1%) of reported serious road accidents
  182 (less than 1%) of reported slight road accidents
  242(less than 1%) of reported all reported road accidents

- "Uncorrected, defective eyesight" was reported as a contributory factor in:

  9 (less than 1%) of reported fatal road casualties
  57 (less than 1%) of reported serious road casualties
  261 (less than 1%) of reported slight road casualties
  327 (less than 1%) of reported all reported road casualties

- Contributory factors are largely subjective, reflecting the opinion of the reporting police officer, and are not necessarily the result of extensive investigation. Some factors are less likely to be recorded. Subsequent enquiries could lead to the reporting officer changing his/her opinion.
- The contributory factors are different from the remainder of the STATS19 data which is based on the reporting of factual information. While this information is valuable in helping to identify ways of improving safety, care should be taken in its interpretation.

Format: Pdf	Cost: Free
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Reported Road Casualties Great Britain 2014**
Author:	Department for Transport
Published:	Department for Transport,2015
Link:	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/463797/rrcgb-2014.pdf
Objectives:	To provide insight into why and how road accidents occur.
Methodology:	Analysis of contributory factors assigned to reported road accidents by police officers attending the accident scenes.

Key Findings:

- In 2014, "Uncorrected, defective eyesight" was reported as a contributory factor in:

  9 (less than 1%) of reported fatal road accidents
  56 (less than 1%) of reported serious road accidents
  195 (less than 1%) of reported slight road accidents
  260(less than 1%) of reported all reported road accidents

- "Uncorrected, defective eyesight" was reported as a contributory factor in:

  11 (1%) of reported fatal road casualties
  66 (less than 1%) of reported serious road casualties
  307 (less than 1%) of reported slight road casualties
  384 (less than 1%) of reported all reported road casualties

- Contributory factors are largely subjective, reflecting the opinion of the reporting police officer, and are not necessarily the result of extensive investigation. Some factors are less likely to be recorded. Subsequent enquiries could lead to the reporting officer changing his/her opinion.
- The contributory factors are different from the remainder of the STATS19 data which is based on the reporting of factual information. While this information is valuable in helping to identify ways of improving safety, care should be taken in its interpretation.

Format: Pdf	Cost: Free
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Driving Facts**
Author:	Specsavers
Published:	Specsavers, undated
Link:	http://www.specsavers.co.uk/eye-health/driving-and-the-law/driving-facts/
Objectives:	To assess the number of drivers with eyesight below the legal minimum and attitudes to eyesight testing for drivers.
Methodology:	Public Opinion survey with 2,000 respondents.

Key Findings:

- As many as 3.5m people could be driving with eyesight below the legal minimum.
- 22% of British drivers who need glasses or contact lenses have knowingly driven without them.
- It is mostly younger drivers who do so: 35% of 17-24 year olds do not always drive with their eyewear compared to about 20% of 45-54 year olds.
- 92% of drivers are in favour of compulsory eye examinations for drivers every five years, particularly for the over 40s.
- 53% were also in favour of random roadside testing of drivers' eyesight.
- 1 in 3 drivers may not have had an eye test in the last two years.
- 80% of those surveyed believe that drivers over 40 years old should have their vision re-tested regularly.
- 65% thought that carrying a spare pair of corrective glasses should be required by law.
- 57% of drivers requiring corrective eyewear did not carry a spare pair of glasses with them when driving.

Format: Pdf	Cost: Free
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Fit to Drive: a cost benefit analysis of more frequent eyesight testing for UK drivers**
Author:	Deloitte Access Economics
Published:	RSA Insurance Group plc, 2012
Link:	http://news.rsagroup.com/assets/view/808
Objectives:	To present a cost-benefit analysis of the case for changing the UK's eyesight test for driving and of a campaign to encourage drivers to voluntarily have their eyes tested every two years.
Methodology:	Literature review and cost-benefit analysis.

Key Findings:

- The RSA is seeking a change in UK law requiring everyone applying for a motorcycle or car licence to have had an eyesight test in the previous two years demonstrating that their vision meets the legal standard.
- It also recommends drivers voluntarily have their eyesight tested more regularly to ensure their vision is up to standard.
- A meta-analysis conducted for the EC IMMORTAL programme reported significant associations with static visual acuity, useful field of view, failing a licence screening test, glare sensitivity and monocular vision.
- Driver eyesight surveys are scarce but generally report around 1 - 3% of drivers (all ages) having VA < 0.5, the EC minimum legal level for driving.
- The IMMORTAL programme estimated the benefits of the EC Directive visual standard in the Czech Republic, Netherlands, Norway and Spain, and reported negative benefits overall. These arose mostly from the costs of withdrawing driving licences from drivers whose eyesight could not be corrected.
- In Great Britain the number of accidents due to poor vision cannot be calculated from the DFT data, since 'uncorrected, defective eyesight' is likely to be under-reported and misinterpreted.
- However, this study estimated that 2,048 drivers in the UK were involved in road accidents due to poor vision, causing an estimated 2,874 casualties, (assuming 2.4% of drivers have poor vision) and the relative risk of accident involvement from poor vision is 1.15.
- The total cost of UK road accidents due to poor driver vision is estimated to be £32.9 million in 2012.
- The proposed policy change is expected to generate almost 500,000 eyesight tests per year. The additional cost of these tests and required spectacles is estimated to be £13.2 million, including £8.0 million to the UK Government.
- From year two onwards the cost savings from fewer road accidents will outweigh these costs, with a maximum net benefit of £14.4 million per year reached by year 10. Net benefits to the UK Government would be realised after eight years.
- It is estimated that a campaign leading to more eyesight tests in the next two years only (a one-off impact) would generate net annual benefits of £32.9 million, including £9.5 million to the UK Government.
- The CBAs required a number of assumptions and the net impact of the assumptions is ambiguous. They do not consider the additional net benefits from early detection of cataracts and glaucoma in older drivers.

Format: Pdf	Cost: Free
Themes:	Eyesight and Driving, Fitness to Drive

<table>
<tr><td>Title:</td><td>Vision and drivers: a South Wales survey</td></tr>
<tr><td>Author:</td><td>S Anuradha, C Potter and G Fernquest</td></tr>
<tr><td>Published:</td><td>Journal of Public Health, 29 (3), 28 September 2007</td></tr>
<tr><td>Link:</td><td>www.ingentaconnect.com/search/article?option1=tka&value1=eyesight+and+driving&pageSize=10&index=3</td></tr>
<tr><td>Objectives:</td><td>To identify the prevalence of drivers failing to meet the visual requirements for driving as laid down by the Driver and Vehicle Licensing Agency (DVLA).</td></tr>
<tr><td>Methodology:</td><td>A random sample of 301 drivers and motorcyclists was stopped under police supervision. 298 of those stopped completed a questionnaire and an eyesight test in which they read a vehicle registration plate at set distances in daylight (similar to the number plate test in the UK practical driving test.</td></tr>
<tr><td colspan="2">Key findings:
The eyesight of 5 of the 298 drivers and motorcyclists tested failed to meet the DVLA standard for driving. This translates to 26,776 drivers in Wales and over half a million drivers in the UK.
The failure rate was greater among drivers older than 40 years of age with one in 45 drivers failing the number plate test in that age group.
There is an urgent need to raise public awareness and instigate personal responsibility among drivers to maintain the required vision for driving.
The magnitude of the problem raises the debate about licence renewal based on periodic mandatory vision testing and the adequacy of the current visual standards used for drivers.
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<tr><td>Format: Pdf</td><td>Cost: Priced</td></tr>
<tr><td>Themes:</td><td>Eyesight and Driving, Fitness to Drive</td></tr>
</table>

Title:	**Optical Confederation Submission to the Transport Select Committee Inquiry into the Government's Strategic Framework for Road Safety**
Author:	Optical Confederation
Published:	Optical Confederation, 2011
Link:	http://centrallobby.politicshome.com/fileadmin/epolitix/stakeholders/Optical_Confederation_Transport_Select_Committee.pdf
Objectives:	To present the case for a change to the UK's eyesight test for drivers.
Methodology:	Submission to House of Commons Transport Select Committee.

Key Findings:

- The number plate test taken during the practical driving test is inadequate. It fails to produce consistent results that are in line with the European visual acuity standard of 6/12.
- Under the current system, drivers are required to self report when they realise their vision fails to meet the legal standard. As changes in eyesight occur gradually, it may not be immediately noticeable that that there is a problem.
- The numbers of licences revoked for poor eyesight does not equate to the 1.8 million people in the UK estimated to have vision below the driving standard of 6/12 (which does not include those with visual field problems).
- The ageing population and other demographic changes mean the number of people with vision below the driving standard will increase to 4 million by 2050.
- A certified assessment of visual acuity, and where necessary visual fields, in a controlled environment, performed by a healthcare professional, should be performed in advance of issuing a provisional driving licence and as part of licence renewal.
- This would ensure that drivers meet the current standard when they renew their licence, and present an opportunity to provide advice on vision and driving e.g. at night time when many drivers report problems.
- While this would carry a modest cost for motorists, there would be offsetting benefits which would reduce road crashes and uncover undetected avoidable sight loss.
- Awareness raising initiatives to highlight the importance of always driving with good vision are important, but must be reinforced by regular assessments of vision as part of licence renewal.

Format: Pdf	Cost: Free
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Aging, Driving and Vision**
Author:	Wood, Joanne M
Published:	Clinical and Experimental Optometry, 85(4), 2002
Link:	http://eprints.qut.edu.au/12003/
Objectives:	To provide an overview of some of the complex issues associated with older drivers and consider how the aging changes in visual function might impact on driving performance.
Methodology:	Literature Review

Key Findings:

- . Visual impairment becomes significantly more prevalent with increasing age, due to the normal aging process and the increased prevalence of eye disease. These changes lead to the reductions in light sensitivity, increased glare sensitivity and reduced visual acuity observed in older populations. Older drivers are more severely restricted in their ability to turn their heads and this has a significant impact on their useful field of vision.
- The prevalence of ocular disease increases with increasing age, with cataracts, glaucoma and age-related maculopathy (ARM) being the most commonly occurring ocular diseases in the older population.
- Visual acuity is probably the most commonly tested visual function for driving and has been shown to decrease significantly with increasing age, particularly after the age of 70 years. However, the evidence linking decreased visual acuity and crash rates is equivocal.
- A study of more than 13,000 drivers found that crash rates were higher in those drivers with poor visual acuity than in those with good visual acuity. Another study of 1,000 drivers found an association between crash rates and visual acuity (both monocular and binocular) and hyperoria. Conversely, a study of more than 17,000 drivers found only a very weak correlation between visual acuity and crash rates, even when the sample was stratified for age, while a further study found that crash rates were elevated only in drivers with reduced visual acuity when their binocular vision was also reduced. Other studies have shown that when visual acuity is reduced, the ability to recognise signs and self-reported driving proficiency was not greatly impaired.
- Visual field sensitivity decreases with increasing age. Early studies found no relationship between the extent of the visual field and crash rates, but, using more reliable visual field measures, a large study of 10,000 drivers, showed that drivers with visual field loss in both eyes had crash rates that were more than twice as high as an age- and sex-matched control group with normal visual fields.
- Dynamic visual acuity (the ability to resolve the fine detail of a moving target) also decreases with increasing age and has been reported to have a higher correlation with crashes than any other visual function. Although significant, the correlations are still low, accounting for only about 5% of the variance in crash rates. A major problem with dynamic visual acuity is that there is no standard way of measuring it, which is why dynamic visual acuity has not been adopted as a vision standard for driving anywhere in the world.
- Little is known about the role of binocular vision for driving. Although some early studies suggested that monocular drivers had increased crash rates, more recent studies have reported that drivers who are, or become monocular,

experience no compromise to their driving performance. • The relationship between colour vision defects and driving performance is controversial. An early study of 298 bus drivers found no relationship between colour deficiency and increased crash rates, while another reported that the prevalence of defective colour vision was almost twice as great in a sample of ‘crash involved’ drivers as in their control group although. • These inconsistencies arise in part from the wide variation in methods used for assessing vision and driving performance. More recent studies have used visual performance measures that provide a better functional representation of real world performance. They have been more consistent in finding a relationship between vision and crash rates, particularly in older drivers. • The ‘useful field of view’ (UFOV) is one such test and relies on higher-order processing skills, such as selective and divided attention and rapid visual processing speed, which are believed to better reflect the driving problems experienced by older adults. • One study reported that the UFOV was better able to identify crash frequency in a group of older drivers than other measures. A three year study reported that those older drivers with 40% or more reduction in their UFOV were 2.2 times more likely to have a crash compared with controls. • There have been several reports of an increased crash risk in drivers with ocular disease. Drivers with glaucoma have been shown to be 3.6 times more likely to be involved in crashes than those with normal vision and those with cataracts had 2.5 times more crashes than a group of age-matched controls.	
Format: Pdf	Cost: Free
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Vision and Driving**
Author:	Department for Transport
Published:	Department for Transport,2002
Link:	http://webarchive.nationalarchives.gov.uk/20100202151600/http://www.dft.gov.uk/pgr/roadsafety/research/rsrr/theme3/visionanddrivingno02
Objectives:	To review literature relating to the effectiveness of various visual tests in predicting the accident-proneness of individual drivers.
Methodology:	Literature Review

Key Findings:

- Although visual performance by most tests steadily declines after early middle age, older drivers have fewer accidents than their younger counterparts, whose visual performance is superior.
- Correlations between poor vision as assessed by some tests and accident rates can be shown in large samples of drivers
- However, as yet, no single test or combination of tests has been shown to be able to effectively screen out those at risk of accidents without also leading to the disqualification of a substantial number of potentially safe drivers.
- No change in the present visual requirements is recommended.

Format: Pdf	Cost: Free
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Vision and Driving**
Author:	Owsley C and McGwin Jr G.
Published:	Vision Research; 50(23), 2010
Link:	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2975746/
Objectives:	To critically review current knowledge about the role of various aspects of visual function in driving, and to discuss translational research issues on vision screening for licensure and re-licensure and rehabilitation of visually impaired persons who want to drive.
Methodology:	Literature Review

Key Findings:

- Many studies have indicated that visual acuity is, at best, very weakly linked to crash risk and so is a poor screening test for identifying drivers who are at-risk.
- However, it is clear that visual acuity is related to certain aspects of driving performance (e.g., road sign recognition).
- Licensing authorities and policy makers are unlikely to give up visual acuity screening tests for driver applicants because of their public acceptance, and association with highway sign legibility.
- A more practical approach to improving the efficacy of vision screening at licensure is to examine how visual acuity screening tests could be supplemented by other types of screening approaches, like contrast sensitivity, visual field, processing speed, and divided attention tests, some of which have a large evidence-basis for their relevance to driver safety.
- Well-designed population-based prospective studies on drivers are needed to identify the effectiveness of these vision screening tests both singly and in combination, in terms of their ability to identify the drivers who experience at-fault crashes in the future.
- Basic research on eye and head movements, scanning, visual search and attention during the driving task has high relevance to the rehabilitation of drivers with vision impairments. This can contribute to developing interventions and training strategies for drivers with visual impairments in the range of 20/40 to 20/200 so that they can remain behind the wheel as long as it is safely possible for them to do so. The effectiveness of these interventions will need to be rigorously evaluated.
- This also applies to BTS devices and training programs, especially since BTS studies to date have been inconclusive with respect to both safety and performance, and many of these studies have methodological problems.
- Basic research on vision and driving, especially scanning and visual search, can also inform the design of training interventions for novice drivers (usually teenagers and young adults) who have the highest rate of collision involvement of all age groups.
- It is conceivable that vehicle technologies could compensate, at least in part, for vision impairments typical of advanced age, and conversely other designs could exacerbate the negative effects of these visual deficits.

Format: Pdf	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Interaction between visual status, driver age and distracters on daytime driving performance**
Author:	J Wood, A Chaparro and L Hickson
Published:	Vision Res. 2009; 49(17), 2009
Link:	http://mres.gmu.edu/pmwiki/uploads/Main/hfacMOD2010.pdf
Objectives:	To investigate the effects of visual status, driver age and the presence of secondary distracter tasks on driving performance.
Methodology:	Twenty young (7 females and 13 males, aged 22 – 31 years) and 19 old (9 females and 10 males, aged 63 – 78 years) participants drove around a closed-road circuit under three visual conditions (normal, simulated cataracts, blur) and three distracter conditions (none, visual, auditory).

Key Findings:

- Simulated visual impairment, increased driver age and the presence of a distracter task detrimentally affected all measures of driving performance except gap judgments and lane keeping.
- Significant interaction effects were evident between visual status, age and distracters
- Simulated cataracts resulted in a greater impairment in driving performance for the older compared to the younger drivers.
- Simulated visual impairment significantly reduced overall driving scores, reducing the number of road signs participants were able to read and slowing their performance on the course.
- It may be that participants are better able to adapt to blur than to simulated contrast sensitivity loss, given that optical blur is more commonly encountered in everyday activities when individuals fail to wear an appropriate spectacle correction, whereas loss of contrast sensitivity is encountered less commonly.
- Gap judgment and lane keeping ability were not affected by visual status; this may potentially be explained by the high contrast nature of the cones used for this task, which may provide adequate visual cues to gap size even with visual impairment.
- The worst performance overall was found with the combination of simulated cataracts, and visual distracters, which is highly relevant to the problems of increased visual impairment in older drivers.
- Cataracts might also compromise older drivers' effectiveness in multitasking. Older participants commented that they often felt uncomfortable when taking their eyes off the road to look at the visual display, especially under the cataract condition.

Format: Pdf	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Cumulative meta-analysis of the relationship between useful field of view and driving performance in older adults: current and future implications**
Author:	Clay OJ, Wadley VG, Edwards JD, Roth DL, Roenker DL, Ball KK
Published:	Optom. Vis. Sci. 82(8), 2005
Link:	http://journals.lww.com/optvissci/Fulltext/2005/08000/Cumulative_Meta_analysis_of_the_Relationship.15.aspx
Objectives:	To examine the relationship between the Useful Field of View (UFOV) assessment and objective measures of retrospective or concurrent driving performance, including reported accidents, on-road driving, and driving simulator performance.
Methodology:	A meta-analysis of eight studies that reported bivariate relationships between Useful Field of View (UFOV) and objective driving measures in order to determine whether a sufficient number of studies have been conducted to validate the relationship between UFOV and driving performance.

Key findings:

- The UFOV is the visual field over which information can be acquired in a brief glance without head or eye movements.
- The UFOV test measures the ability to process rapidly presented, complex information with a single glance.
- Poorer UFOV performance was associated with negative driving outcomes.
- This relationship was robust across multiple indices of driving performance and several research laboratories.
- This convergence of evidence across numerous studies using different methodologies confirms the importance of the UFOV assessment as a valid and reliable index of driving performance and safety.
- UFOV was most strongly correlated with at-fault crashes, whereas visual acuity and contrast sensitivity tests were only modestly correlated with at-fault crashes
- Recent studies have confirmed a relationship between UFOV performance and future crashes, further supporting the use of this instrument as a potential screening measure for at-risk older drivers.

Format: Pdf	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

<table>
<tr><td>Title:</td><td>Useful Field of View Predicts Driving in the Presence of Distracters</td></tr>
<tr><td>Author:</td><td>Wood JM, Chaparro A, Lacherez P and Hickson L.</td></tr>
<tr><td>Published:</td><td>Optom. Vis. Sci.; 89(4), 2012</td></tr>
<tr><td>Link:</td><td>http://eprints.qut.edu.au/49216/1/49216.pdf</td></tr>
<tr><td>Objectives:</td><td>To examine whether the effectiveness of the Useful Field of View test in predicting crash risk among older adults is due to the ability of the UFOV to predict difficulties in attention-demanding driving situations that involve either visual or auditory distracters.</td></tr>
<tr><td>Methodology:</td><td>92 community-living adults, aged 65-88 years, completed all three subtests of the UFOV test involving assessment of visual processing speed, divided attention, and selective attention. Driving performance was assessed on a closed-road circuit while driving under three conditions: no distracters, visual distracters, and auditory distracters.</td></tr>
<tr><td colspan="2">Key Findings:
UFOV significantly predicted driving performance both in the presence and absence of visual or auditory distracters.
UFOV predicted interference in the distracter conditions, such that those who were scored as safe experienced less decrement in driving performance in the presence of distracters than those scored as unsafe.
Driving problems caused by visual or auditory distracters are greatest for those who are rated most at risk for crashing overall.
Participants who rated as safe on the UFOV, as well as those responding faster than the recommended cut-off on the selective attention subtest (350 msec), performed significantly better in terms of overall driving performance and also experienced less interference from distracters.
Of the three UFOV subtests, the selective attention subtest best predicted overall driving performance in the presence of distracters.
Older adults who were rated as higher risk on the UFOV, particularly on the selective attention subtest, demonstrated the poorest driving performance in the presence of distracters.
This finding suggests that the selective attention subtest of the UFOV may be differentially more effective in predicting driving difficulties in situations of divided attention which are commonly associated with crashes.
</td></tr>
<tr><td>Format: Pdf</td><td>Cost: Priced</td></tr>
<tr><td>Themes:</td><td>Eyesight and Driving, Fitness to Drive</td></tr>
</table>

Title:	**The impact of visual field loss on driving performance: evidence from on-road driving assessments**
Author:	L Racette and EJ Casson
Published:	Optometry and Vision Science; 82(8), 2005
Link:	http://trid.trb.org/view.aspx?id=767076
Objectives:	To investigate the relationship between visual field loss and driving performance as determined by on-road driving assessments.
Methodology:	The files of 1,350 patients enrolled in a programme between 1976 and 2004 that offered driver rehabilitation after an illness or injury were examined and 131 patients with visual field loss who had undergone an on-road driving assessment were identified. None had substantial motor or cognitive deficits. The participants included 13 hemianopics, 7 quadrantanopics, 25 with monocular vision, 10 with moderate peripheral losses, and 76 patients with mild peripheral losses. The driving assessment took place on roads near the rehabilitation centre, and involved a number of tasks commonly encountered in daily driving. The assessment outcomes were classified as safe, unknown, or unsafe.

Key Findings:

- Some patients with visual field loss are rated as “safe” during on-road driving assessments
- Patients with larger visual field loss (hemianopia and moderate visual field loss) were more likely to be unsafe drivers than patients with smaller visual field loss quadrantanopia and mild visual field loss).
- These results are consistent with previous findings showing that some patients with visual field loss can drive safely under natural driving conditions.
- Predicting whether a patient with a visual field defect will be able to drive safely based on the extent and location of the deficit is difficult. Although the extent and location of the visual field loss may be related to driving performance, large individual differences exist. This highlights the need for individualized on-road assessments for patients with visual field defects.
- Knowing where the deficit is located would not improve the prediction of crash risk, and this information should not be used alone when trying to determine whether an individual may be fit to drive.
- Drivers with monocular vision can drive safely. The main concern with monocular drivers has been their ability to perceive depth, however, depth can be estimated through different cues and its perception does not pose a significant problem when driving.
- No healthy control group was available as a comparison group for this study.

Format: Pdf	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**The effect of visual field defects on driving performance: a driving simulator study**
Author:	Coeckelbergh TR, Brouwer WH, Cornelissen FW, Van Wolffelaar P, Kooijman AC
Published:	Arch Ophthalmol;120(11), 2002
Link:	http://www.ncbi.nlm.nih.gov/pubmed/12427065
Objectives:	To investigate the effect of visual field defects on driving performance, and to predict practical fitness to drive.
Methodology:	The driving performance of 87 subjects with visual field defects due to ocular abnormalities was assessed on a driving simulator and during an on-road driving test.
Key Findings: • Subjects with visual field defects showed differential performance on measures of driving speed, steering stability, lateral position, time to collision, and time-headway. • Effective compensation consisted of reduced driving speed in cases of central visual field defects and increased scanning in cases of peripheral visual field defects. • The sensitivity and specificity of models based on vision, visual attention, and compensatory viewing efficiency were increased when the distance at which the subject started to scan was taken into account. • Driving examiners considered reduced speed and increased scanning to be valid compensation for central and peripheral visual field defects, respectively. • Predicting practical fitness to drive was improved by taking driving simulator indexes into account.	
Format: Pdf	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Self-Reported Driving Difficulty by Persons with Hemianopia and Quadrantanopia**
Author:	Parker, Walter T, McGwin, Gerald, Wood, Joanne M., Elgin, Jennifer, Vaphiades, Michael S, Kline, Lanning B, Cynthia Owsley
Published:	Current Eye Research, Vol 36, No 3, March 2011
Link:	http://informahealthcare.com/doi/abs/10.3109/02713683.2010.548893
Objectives:	To compare self-reported driving difficulty by persons with hemianopic or quadrantanopic field loss with that reported by age-matched drivers with normal visual fields. To examine how their self- reported driving difficulty compares to ratings provided by a certified driving rehabilitation specialist (CDRS).
Methodology:	Questionnaire survey of 17 persons with hemianopic field loss, 7 with quadrantanopic loss, and 24 age-matched controls with normal visual fields, all of whom had driver's licences. On-road driving performance was evaluated by a certified driving rehabilitation specialist.
Key Findings: • Drivers with hemianopic and quadrantanopic field loss expressed significantly more difficulty with driving manoeuvres involving peripheral vision and independent mobility, compared to those with normal visual fields. • Drivers with hemianopia and quadrantanopia who were rated as unsafe to drive based on an on-road assessment by the CDRS were no more likely to report driving difficulty than those rated as safe. • Hemianopia and quadrantanopia affect driving ability, but drivers may not realise it. • Some drivers with hemianopia or quadrantanopia may inappropriately view themselves as good drivers when in fact their driving performance is unsafe as judged by a driving professional. • The aspects of driving that hemianopic or quadrantanopic persons find particularly problematic suggest areas that could be focused on in driving rehabilitation.	
Format: Pdf	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

<table>
<tr><td>Title:</td><td>Hemianopic and Quadrantanopic Field Loss, Eye and Head Movements, and Driving</td></tr>
<tr><td>Author:</td><td>Joanne M. Wood, Gerald McGwin Jr, Jennifer Elgin, Michael S. Vaphiades, Ronald A. Braswell, Dawn K. DeCarlo, Lanning B. Kline and Cynthia Owsley</td></tr>
<tr><td>Published:</td><td>Investigative Opyhalmology & Visual Science, Vol 52(3), 2011</td></tr>
<tr><td>Link:</td><td>http://www.iovs.org/content/52/3/1220</td></tr>
<tr><td>Objectives:</td><td>To compare eye and head movements, lane keeping, and vehicle control of drivers with hemianopic and quadrantanopic field defects with controls, and to identify differences between those drivers rated as safe to drive by a clinical driving rehabilitation specialist compared with those rated as unsafe.</td></tr>
<tr><td>Methodology:</td><td>22 participants (with a current licence or seeking to resume driving) with homonymous hemianopic defects and 8 with quadrantanopic defects (mean age, 53 years) and 30 with normal vision (mean age, 53 years) drove a 6.3-mile route along non-interstate city roads under normal traffic conditions.</td></tr>
<tr><td colspan="2">Key Findings:

As a group, drivers with hemianopic or quadrantanopic defects

Drove slower, exhibited less excessive cornering or acceleration, and executed more shoulder movements than the control group drivers.
Who were rated as safe made more head movements into their blind field and more eye movement than those rated unsafe.
Who were rated as safe kept a more stable lane position, exhibited less sudden braking and drove faster than those rated unsafe.
Who were rated as safe to drive compensated for their vision impairment by making more head and shoulder movements.
Drove more smoothly than those with normal vision, but made significantly more sudden braking events.

Future research should evaluate whether these characteristics could be trained in rehabilitation programs designed to improve driving safety in this population.
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<tr><td>Format: Html</td><td>Cost: Priced</td></tr>
<tr><td>Themes:</td><td>Eyesight and Driving, Fitness to Drive</td></tr>
</table>

Title:	**Evaluation of On-Road Driving in People With Hemianopia and Quadrantanopia**
Author:	Elgin, Jennifer, McGwin, Gerald Jr., Wood, Joanne M., Vaphiades, Michael S., Braswell, Ronald A., DeCarlo, Dawn K., et al, Lanning B Kline and Cynthia Owsley
Published:	Journal of Occupational Therapy, 64(2), 2010
Link:	http://www.ncbi.nlm.nih.gov/pubmed/20437914
Objectives:	To examine whether some drivers with hemianopia or quadrantanopia display safe driving skills on the road compared with drivers with normal visual fields.
Methodology:	An occupational therapist evaluated 60 drivers (31 males and 29 females, aged 33 to 73 years) for driving skills during naturalistic driving using six rating scales, 22 of the drivers had hemianopia, 8 had quadrantanopia, and 30 had normal vision

Key Findings:

- The drivers with hemianopia or quadrantanopia were more likely to be men than those with normal visual fields.
- The number of chronic medical conditions was significantly higher in the field loss groups than in the group with normal visual fields.
- Although the group with hemianopia had slightly worse visual acuity and contrast sensitivity than the group with normal visual fields, their visual acuity was still at a high level, averaging 20/25 or better, as was their contrast sensitivity.
- There was no difference between the group with quadrantanopia and the group with normal visual fields on either acuity or contrast sensitivity.
- Scores for visual processing speed and attentional skills were worse in those with hemianopia compared with those with normal visual fields.
- The percentage of drivers with hemianopia exhibiting problems for all skills evaluated was greater than the percentage of drivers with normal visual fields exhibiting these problems.
- For example, 40.9% of drivers with hemianopia exhibited difficulty with vehicle control skills; 36.3%, adjustment to traffic speed conditions; 27.2%, reaction to unexpected events; and 27.2%, unusually bad driving manoeuvres. The corresponding percentages for drivers with normal visual fields were 6.7%, 6.7%, 0%, and 0%, respectively.
- On non-interstate roads, drivers with quadrantanopia were poorer than drivers with normal fields at adjusting to traffic speed conditions, and made unusually bad driving manoeuvres. However, this difference was largely because of one driver with quadrantanopia who had serious problems on the road.
- On the non-interstate, 100% of drivers with normal visual fields were judged to have the potential for safe driving with no restrictions.
- Compared with drivers with normal visual fields, a lower percentage of drivers with hemianopia (17 of 22, 77.3%) —16 with no restrictions and 1 with restrictions— were judged to have the potential for safe driving.
- Of drivers with quadrantanopia, 7 of 8 (87.5%) were judged to have the potential for safe driving on the non-interstate.
- With respect to interstate driving, it is important to keep in mind that some drivers were not evaluated on the interstate because they preferred not to drive

on the interstate or they were not permitted to do so. • All drivers with normal visual fields except 1 (28 of 29, 96.6%) were judged to have the potential for safe driving with no restrictions on the interstate. • Of those with hemianopia or quadrantanopia who drove on the interstate, most (91.7% and 85.7 respectively) were judged to have the potential for safe driving with no restrictions. • Up to two-thirds of the drivers in our study with hemianopia and quadrantanopia drove with no obvious driving errors or had only a few minor errors on non-interstate roads as assessed by the CDRS and were judged to have the potential for safe driving. • These findings provide strong evidence that some people with hemianopia and quadrantanopia can demonstrate that they are fit to drive if given the opportunity to undergo a standardized on-road evaluation by an occupational therapist who specializes in driving. • These specialists are specifically trained to evaluate drivers who have functional impairments that could potentially interfere with safe driving skills. The CDRS's ratings were in good agreement with those of the backseat evaluator who was masked to drivers' medical and functional characteristics, implying that the results are not attributable to the CDRS's bias on the basis of knowledge of each driver's medical history. • Our data suggest that drivers with better contrast sensitivity and average light sensitivity in the remaining areas of visual field and those with faster processing speeds were more likely to be judged as safe drivers. • These results raise important questions regarding the fairness of government policies that categorically deny licensure to people with hemianopia or quadrantanopia. A more rational and fair policy would be to allow for an individualized assessment of driving fitness for people with these conditions, conducted by an occupational therapist who specializes in driving assessment and rehabilitation. • For drivers with hemianopia who received ratings of unsatisfactory or worse, the most noteworthy problem area was vehicle control skills (e.g., staying in one's lane): about 40% of drivers exhibited this problem to various degrees. • What remains to be determined is whether a driving rehabilitation program (e.g., scanning or visual search training while driving, practice in keeping within the lane) could improve driving skills in problem drivers with hemianopia or quadrantanopia.	
Format: Pdf	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

<table>
<tr><td>Title:</td><td>Even moderate visual impairments degrade drivers’ ability to see pedestrians at night</td></tr>
<tr><td>Author:</td><td>Wood, Joanne M, Tyrrell, Richard A., Chaparro, Alex, Marszalek, Ralph P, Carberry, Trent P, & Chu, Byoung Sun</td></tr>
<tr><td>Published:</td><td>Investigative Ophthalmology and Visual Science, 2012</td></tr>
<tr><td>Link:</td><td>http://www.iovs.org/content/53/6/2586</td></tr>
<tr><td>Objectives:</td><td>To determine the effect of moderate levels of refractive blur and simulated cataracts on nighttime pedestrian conspicuity in the presence and absence of headlamp glare.</td></tr>
<tr><td>Methodology:</td><td>28 young adults (14 male and 14 female, aged 20 to 36 years) drove a closed road course at night, under three visual conditions: normal vision, simulated blurred vision and simulated cataracts. Pairs of headlamps were placed at three locations along the road circuit and two pedestrians wearing black clothes, black clothes with a retro-reflective should belt or black clothes with retro-reflective tape around the waist, elbows, ankles, knees and shoulders, were placed at separate locations.</td></tr>
<tr><td colspan="2">Key Findings:
• Drivers’ ability to see and respond to pedestrians at night is degraded by modest but common visual impairments, even when their visual acuity meets commonly accepted standards for driver licensing.
• Blurred vision (commonly caused by not wearing the correct spectacles or contact lenses) and simulated cataracts both reduced drivers’ ability to recognise pedestrians at night
• Simulated cataracts were significantly more disruptive than simulated blurred vision.
• None of the drivers with simulated cataracts responded to the pedestrians in black clothing.
• Drivers with simulated blurred vision responded to 42% of the pedestrians when there was no headlight glare, but only 6% when there was glare.
• Headlight glare effectively halved the likelihood, of drivers detecting a pedestrian, and significantly decreased the distance at which they were able to do so, no matter what clothing the pedestrians were wearing.
• Drivers with normal vision responded to pedestrians at 3.6 times longer distances than with the simulated blurred vision.
• Drivers with normal vision responded to pedestrians at 5.5 times longer distances than with the simulated cataracts.
• Even with visual impairment and glare, pedestrians were recognised more often and at longer distances when they wore a “biological motion” (retro-reflective tape around the waist, elbows, ankles, knees and shoulders) clothing than when they wore a reflective vest or black clothing.
• Drivers should wear their optimum optical correction, and cataract surgery should be performed early enough to avoid potentially dangerous reductions in visual performance.</td></tr>
<tr><td>Format: Html</td><td>Cost: Priced</td></tr>
<tr><td>Themes:</td><td>Eyesight and Driving, Fitness to Drive</td></tr>
</table>

Title:	**The effect of simulated cataracts on drivers' hazard perception ability**
Author:	Marrington SA, Horswill MS and Wood JM
Published:	Optom. Vis. Sci. 85(12), 2008
Link:	http://www.ncbi.nlm.nih.gov/pubmed/19050466
Objectives:	To investigate the extent to which simulated cataracts slow a driver's ability to anticipate potential traffic hazards.
Methodology:	186 drivers with normal vision (121 females and 65 males, aged 17 to 59 years old) completed a validated video-based hazard perception driving test. They also completed a change detection task based on traffic hazards, which was designed to measure object detection times. Participants undertook the tasks wearing either mild or moderate cataract simulation goggles, or wearing goggle frames without lenses.

Key Findings:

- Cataracts are known to result in a number of visual changes, including decreased contrast sensitivity, susceptibility to glare, and decreased visual acuity, but only contrast sensitivity has been found to be directly associated with increased crash rates
- Participants wearing moderate simulated cataract goggles were significantly slower than the control group in both the hazard perception test, and the hazard change detection task.
- Participants with the mild simulated cataract goggles were slower than the control group in the hazard change detection task, but not the hazard perception test.
- Moderate levels of simulated cataract slowed drivers' ability to detect and anticipate traffic hazards, despite the fact that the vision of participants wearing the cataract goggles still complied with the minimum legal standard required for driving.
- However, the results may have been affected by the fact that in real-life cataracts develop over a long period of time, whereas the simulated cataracts create an immediate change.
- Drivers who meet the current legal standards for driving (based on visual acuity), may be at increased crash risk due to impairments in their ability to detect traffic hazards.
- Many individuals with cataracts continue to drive for months before having cataract surgery (and others may decide not to have surgery at all), which highlights the importance of performing cataract operations as soon as possible if individuals wish to continue driving.
- There are also possible consequences for road design as creating high contrast driving environments may improve hazard detection for those with poor contrast sensitivity. It is also possible that drivers could be given anticipation training in which they could be taught to compensate for their reduced contrast sensitivity by predicting where hazards are likely to occur.

Format: Pdf	Cost: Free
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Bilateral cataract surgery and driving performance**
Author:	Wood, Joanne M. & Carberry and Trent P
Published:	British Journal of Ophthalmology, 90(10), 2006
Link:	http://bjo.bmj.com/content/90/10/1277
Objectives:	To investigate whether cataract surgery can improve driving performance and whether this can be predicted by changes in visual function
Methodology:	29 older patients, aged 50 to 89 years, with bilateral cataracts who were scheduled for cataract surgery and 18 controls with normal vision were tested. All were licensed drivers. Driving and vision performance were measured before cataract surgery and after second eye surgery for the patients with cataracts and on two separate occasions for the control groups. Driving performance was assessed on a closed-road circuit. Visual acuity, contrast sensitivity, glare sensitivity and kinetic visual fields were measured at each test session.

Key Findings:

- Patients with cataracts had significantly poorer driving performance the controls for a range of measures of driving performance, which significantly improved to the level of the controls after extraction of both cataracts.
- Driving performance improved markedly after bilateral cataract surgery compared with a control group, and the improvement was best predicted by the change in contrast sensitivity in the second operated or better eye.
- Bilateral cataract surgery resulted in marked improvements in sign recognition, ability to detect and avoid hazards, and overall driving score. In most cases, these improvements brought the performance of the cataract patients to levels similar to those of the controls.
- This provides objective evidence of specific improvements in driving skills after cataract surgery and has important implications for road safety of older drivers.
- Similarly, self-reported data suggest that 25% of patients with cataract who had ceased to drive before surgery resumed driving afterwards.
- Bilateral cataract surgery also resulted in improvements in both binocular and monocular visual acuity, contrast sensitivity and BAT glare sensitivity, which is in agreement with previous studies.

Format: Pdf	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Effect of presbyopic vision corrections on perceptions of driving difficulty**
Author:	Chu, Byoung-Sun, Wood, Joanne M., & Collins, Michael J
Published:	Eye and Contact Lens : Science & Clinical Practice, 35(3), 2009
Link:	http://eprints.qut.edu.au/30003/
Objectives:	To determine the subjective driving difficulties experienced when wearing a range of common presbyopic contact lens and spectacle corrections.
Methodology:	1,350 questionnaires were sent to Optometry clinics in Australia. 324 were returned (24%), but only 255 (19%) were used for analysis. The mean age of respondents (47% male and 53% female) was 55 years. The participants were categorized into five age-matched groups: those wearing no vision correction for driving (n = 50), bifocal spectacles (n = 54), progressive spectacles (n = 50), monovision contact lenses (n = 53), and multifocal contact lenses (n = 48).

Key Findings:

- Overall, ratings of satisfaction during daytime driving were relatively high (80%+) for all types of vision correction.
- However, multifocal contact lens wearers were significantly less satisfied with aspects of their vision during night-time than daytime driving, particularly with disturbances from glare and haloes.
- Progressive spectacle lens wearers noticed more distortion of peripheral vision, whereas bifocal spectacle wearers reported more difficulties with tasks requiring changes of focus
- Those who wore no optical correction for driving reported problems with intermediate and near tasks.
- Overall, satisfaction was significantly higher for progressive spectacles than bifocal spectacles for driving.
- Subjective visual experiences of different presbyopic vision corrections when driving vary depending on the vision tasks and lighting level.
- Eye-care practitioners should be aware of the driving-related difficulties experienced with each vision correction type and the need to select corrective types that match the driving needs of their patients.

Format: Pdf	Cost:
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**The Effect of Presbyopic Vision Corrections on Nighttime Driving Performance**
Author:	Chu, Byoung S., Wood, Joanne M., & Collins, Michael J.
Published:	Investigative Ophthalmology & Visual Science, 51(9), 2010
Link:	http://www.iovs.org/content/51/9/4861
Objectives:	To investigate the effect of various presbyopic vision corrections on night-time driving performance on a closed-road driving circuit.
Methodology:	11 drivers aged 51 to 63 years (5 females and 6 males) with presbyopia who did not normally use vision correction when driving drove at night on a closed-road circuit while wearing each of four vision corrections: single-vision distance spectacles, progressive-addition spectacles, monovision contact lenses, and multifocal contact lenses. Low-contrast road hazard detection and avoidance, road sign and near target recognition, lane-keeping, driving time, legibility distance for street signs, and eye movements were recorded.

Key Findings:

- Surveys have shown that many forms of presbyopic corrections are associated with problems with driving under low-illumination levels.
- Night-time driving on a closed-road circuit is significantly affected by the use of different types of presbyopic vision correction.
- Multifocal contact lenses negatively affected more of the driving performance measures, and spectacles performed better than the contact lenses.
- Single vision distance lens wearers showed significant loss of performance for recognition of near targets, such as the radio and speedometer.
- Wearing multifocal contact lenses resulted in significantly slower driving speeds than wearing progressive-addition spectacles, presumably as a result of poorer overall vision leading to more cautious driving.
- Multifocal contact lenses increased the likelihood of hitting a low-contrast object on the road, with the difference approaching statistical significance.
- The mean distance to read a street sign was approximately 60m with single vision distance lens and progressive-addition spectacles, 48m with monovision contact lenses and 38m with multifocal contact lenses.
- There was no significant differences between the types of vision correction and the number of road signs correctly recognized (61% - 64%)
- However, when text signs (not speed limit signs) were correctly recognised there were differences in fixation duration between the types of vision correction - monovision and multi-focal contact lenses resulted in significantly longer fixation durations.
- The distance at which a standard street sign was recognised varied between types of vision correction; they were recognised at significantly longer distances with single-vision distance lenses, progressive-addition spectacle lenses and monovision contact lenses, than with multifocal contact lenses.

Format: Pdf	Cost:
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Medical Conditions and Driving: A Review of the Scientific Literature (1960-2000)**
Author:	Bonnie M. Dobbs, Ph.D.
Published:	Association for the Advancement of Automotive Medicine, September 2005
Link:	http://www.nhtsa.gov/people/injury/research/medical_condition_driving/pages/TRD.html
Objectives:	To provide a comprehensive analysis of the international research literature on the effects of medical and functional conditions on driving performance.
Methodology:	Literature review

Key Findings:

Myopia

- Night myopia is relatively commonly in young myopic patients, possibly because of changes that are absent after the age of about 50 years.
- Research from 1992 that indicated that, of a sample of 380 randomly selected patients, 38% had night myopia of 0.75 dioptres, 23% had night myopia of 1.00 dioptres or more, and 4% night myopia of 2.50 dioptres (which is equivalent to an acuity of 20/265).
- Results of trials with corrective lenses in night driving conditions were varied with some drivers reporting improved night vision and others reporting worsening vision.
- Night myopic lenses are not always effective, which may warrant restrictions in nighttime driving for those individuals without corrective lenses.
- Because of the reported high prevalence of night myopia in younger drivers, it may be prudent to include questions regarding ability-to-see-at-night during licensing of younger drivers.

Colour Vision

- There are few studies available with data relevant to colour vision defects and crash rates.
- However, some studies have found that individuals who are red colour-blind (protanope) appear to have almost twice as many rear-end collisions as those with both red and green colour deficits (deutans) and normals.
- Results from one study suggest that individuals with colour vision defects have difficulty, in general, when driving. 29% of 102 individuals with congenital colour blindness who were sent a questionnaire reported having difficulty distinguishing the colour of traffic signal lights, 325 said they had confused traffic lights with streetlights, and 13% reported having difficulty in detecting brake lights on other cars.
- Despite the reported difficulties with colour vision discrimination while driving, it is unlikely that colour vision impairments, in general, represent a driving hazard, particularly now that the position of traffic lights has been generally standardised.

Format: Pdf	Cost: Free
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Relationship between night myopia and night-time motor vehicle accidents**
Author:	Cohen Y, Zadok D, Barkana Y, Shochat Z, Ashkenazi I, Avni I, Morad Y.
Published:	Acta Ophthalmol Scand. 2007 Jun;85(4):367-70.
Link:	http://www.ncbi.nlm.nih.gov/pubmed/17335516
Objectives:	To investigate the relationship between night myopia and the occurrence of night-time motor vehicle accidents in a group of professional drivers.
Methodology:	136 professional drivers took eye tests in full illumination and after sitting in darkness for 5 minutes. The change in refraction, indicative of night myopia, was correlated with the number of motor vehicle accidents in which each driver was involved and with the results of a visual complaints questionnaire.

Key Findings:

- The mean age of the study group was 21.0 years. Mean spherical refraction changed from + 0.11 dioptres (D) in light to -0.17 D after dark adaptation for 5 minutes.
- Night myopia was found in 34 drivers (25%), at a mean of -1.2 D (range -0.75 D to -3.50 D).
- There was no statistically significant difference between these drivers and the rest of the group in the results of the visual complaints questionnaire, or in the number of accidents occurring during the day.
- However, drivers with a myopic shift > 0.75 D were involved in more accidents at night than the rest of the group (p = 0.044).
- In this study population, drivers with night myopia of > 0.75 D were more likely to be involved in night-time accidents.
- This may imply that selected groups of drivers should be examined for night myopia.

Format: Pdf	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Driver Health and Crash Involvement: A Case-Control Study**
Author:	Sagberg, Fridulv
Published:	Accident Analysis & Prevention, Volume: 38, Issue 1, 2006
Link:	http://www.sciencedirect.com/science/article/pii/S0001457505001156
Objectives:	To examine the relative crash involvement risk associated with diagnosed medical conditions, subjective symptoms, and various medicines.
Methodology:	A case control study using self-report questionnaires from 4,448 drivers of all ages involved in automobile collisions.

Key Findings:

- Relative risk for each health condition was estimated by comparing drivers with and without the condition, regarding the odds of being at fault for the crash.
- One of the significant risk factors observed was myopia (OR = 1.22).

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Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Night Myopia: A Consideration In Graduated Driver Licensing Systems**
Author:	White Jr, G L, Mamalis, N and Spellicy, M J
Published:	The Chronicle, Volume: 48, Issue 4, 2000
Link:	http://trid.trb.org/view/2000/C/677859
Objectives:	To comment on the implications of the findings of about night myopia in “Medical Conditions and Driving: A Review of the Scientific Literature (1960-2000)”
Methodology:	Comment piece

Key Findings:

- Night myopia is a relatively common condition in which increasing nearsightedness is seen when a patient is in a low contrast conditions such as that noted with night driving, or driving in inclement weather conditions.
- It is seen relatively commonly in young myopic patients. Approximately 38% of young patients (aged 16-25 years) are deemed to have Night myopia, with 4% having Night myopia of 2.50 diopters.
- This article discusses the measurement of the magnitude of Night myopia, the causes of Night myopia and treatment effectiveness, and other aspects of this condition as it relates to younger drivers.
- The subject of graduated driver licensing programs is discussed as a possible means of dealing with the prevalence of Night myopia among younger drivers.

Format: Pdf	Cost: Free
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Comparison of Night Driving Performance after Wavefront-Guided and Conventional LASIK for Moderate Myopia**
Author:	Schallhorn, Steve C, Tanzer, David J, Kaupp, Sandor E, Brown, Mitch and Malady, Stephanie E
Published:	Ophthalmology, Volume: 116, Issue 4, 2009
Link:	http://trid.trb.org/view/890958
Objectives:	To compare pre-operative and post-operative changes in simulated night driving performance after two types of laser eye surgery to treat moderate myopia.
Methodology:	A night driving simulator (NDS) test with 38 cLASIK patients and 21 wLASIK patients, none of whom were older than 51 years.

Key Findings:

- The results showed that in every category, there was a mean reduction in the pre-operative to post-operative NDS performance after cLASIK. There was a corresponding mean improvement after wLASIK.
- Significant differences between cLASIK and wLASIK NDS performance was observed in every category.
- A clinical relevant loss of NDS performance (greater than 0.5 seconds) was observed in 32% to 38% of cLASIK eyes for all tasks, whereas only 0% to 3% of eyes had this loss after wLASIK.
- Between 2% and 7% of cLASIK eyes and 11% and 31% of wLASIK eyes had a significant postoperative improvement in NDS performance in every task.
- Wavefront-guided LASIK to correct myopia combined with a femtosecond laser flap significantly improved mean night driving visual performance and was significantly better than cLASIK using a mechanical keratome.

Format: Pdf	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Night driving simulation in a randomized prospective comparison of Visian toric implantable collamer lens and conventional PRK for moderate to high myopic astigmatism**
Author:	Schallhorn S, Tanzer D, Sanders DR, Sanders M, Brown M, Kaupp SE.
Published:	J Refract Surg. 2010 May;26(5):321-6
Link:	http://www.ncbi.nlm.nih.gov/pubmed/20506988
Objectives:	To compare changes in simulated night driving performance after lens implantation and or laser eye surgery to correct moderate to high myopic astigmatism.
Methodology:	A prospective, randomized study consisted of 43 eyes implanted with a particular type of contact lens and 45 eyes receiving conventional laser surgery for moderate to high myopia. As a sub-study, 27 eyes of 14 lens patients and 41 eyes of 21 laser patients underwent a simulated night driving test. The detection and identification distances of road signs and hazards with the Night Driving Simulator were measured with and without a glare source before and 6 months after each procedure.

Key Findings:

- No significant difference was noted in the pre- to post-operative Night Driving Simulator in detection distances with and without the glare source between the two groups.
- The differences in identification distances without glare were significantly better for business and traffic road signs and pedestrian hazards in the lens group relative to the laser group whereas with glare, only the pedestrian hazards were significantly better.
- A clinically relevant change of Night Driving Simulator performance (>0.5 seconds change in ability to identify tasks postoperatively) was significantly better in the lens group (with and without glare) for all identification tasks.
- The lens performed better than conventional laser surgery in the pre- to postoperative Night Driving Simulator.

Format: Pdf	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**The visual and driving performance of monocular and binocular heavy-duty truck drivers**
Author:	A.J. McKnight, D. Shinar, B. Hilburn
Published:	Accident Analysis & Prevention, Volume 23, Issue 4, August 1991
Link:	http://www.ncbi.nlm.nih.gov/pubmed/1883464
Objectives:	1. To analyse and identify aspects of visual performance that might be affected by monocularity, and the driving functions of truck drivers that are likely to be significantly affected by the reduced visual performance. 2. To identify and formulate specific measures of visual and driving performance 3. To compare the visual and driving performance of monocular and binocular truck drivers.
Methodology:	40 monocular and 40 binocular truck drivers with an average age of 44 to 46 years and an average mileage of 58,000 to 61,000 km underwent 8 visual performance tests and driving performance tests on street and off street while being filmed.

Key Findings:

- The comparison of the visual and driving performance of 40 monocular and 40 binocular truck drivers found that the mononuclear drivers were significantly deficient in contrast sensitivity, visual acuity in low light levels and glare, and binocular depth perception.
- They were not significantly deficient in static or dynamic visual acuity, visual field of individual eyes, or glare recovery.
- There was no difference in visual search, lane keeping, clearance judgment, gap judgment, hazard detection, and information recognition between monocular and binocular drivers.
- However, monocular drives were poorer than binocular drivers in contrast sensitivity, depth perception, minimal illumination for night vision and glare resistance.
- This meant that the distance at which the monocular drivers could read signs was on average 13% or 5.6 metres shorter in the day than the binocular drivers, and, on average 12 % or 3 metres shorter at night.
- The total visual field of the monocular drivers (on average 145 degrees) was significantly smaller than that of the binocular drivers (on average 173 degrees)
- Overall, monocular drivers have some significant reductions in certain visual capabilities in some driving functions that depended on these abilities, compared with binocular drivers. But, they are not significantly worse than binocular drivers in most driving functions.

Format: Pdf	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Incidence of visual field loss in 20,000 eyes and its relationship to driving performance**
Author:	Johnson CA and Keltner J
Published:	Archives of Ophthalmology; 101: 1983
Link:	http://www.ncbi.nlm.nih.gov/pubmed/6830485
Objectives:	To assess the incidence of visual field loss and its relationship to driving performance
Methodology:	Automated visual field screening of 10,000 volunteers (20,000 eyes)
Key Findings: • The incidence of visual field loss was 3.0% to 3.5% for persons aged 16 to 60 years but was approximately 13.0% for those older than 65 years. • Approximately half of the persons with abnormal visual fields were previously unaware of any problem with peripheral vision. • Follow-up results suggested that the most common causes of visual field loss were glaucoma, retinal disorders, and cataracts. • Drivers with binocular visual field loss had accident and conviction rates twice as high as those with normal visual fields. • Drivers with monocular visual field loss had accident and conviction rates equivalent to those of a control group. • The results have important implications for mass visual field screening to detect eye diseases and for vision-related factors in traffic safety.	
Format: Pdf	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Night driving self-restriction: vision function and gender differences**
Author:	Brabyn JA, Schneck ME, Lott LA, Haegerström-Portnoy G.
Published:	Optom Vis Sci. 2005 Aug;82(8):755-64.
Link:	http://www.ncbi.nlm.nih.gov/pubmed/16127342
Objectives:	To evaluate gender differences in the relationship between night driving self-restriction and vision function in an older population
Methodology:	Night driving self-restriction patterns (assessed by questionnaire) were examined in relation to age, gender, health and cognitive status, depression, and vision function in a sample of 900 older people (mean age, 76 years) living in Marin County, California

Key Findings:

- Among current drivers, women had slightly better vision function than men on most measures (low-contrast acuity, contrast sensitivity, low-contrast acuity in glare, low-contrast, low-luminance acuity, and glare recovery) but were twice as likely as men to restrict their driving to daytime.
- Men showed significant associations with avoidance of night driving on four spatial vision measures (high- and low-contrast acuity, low-contrast, low-luminance acuity, and contrast sensitivity).
- For women, in addition to these measures, a significant association was seen for low-contrast acuity in glare.
- Neither men nor women showed significant associations between driving restriction and performance on the other vision measures examined (glare recovery time, attentional field integrity, or stereopsis).
- The vision measures most predictive of self-restriction were contrast sensitivity for men and low-contrast acuity in glare for women.
- Including both cessation and self-restriction, men over age 85 years are 6.6 times more likely than women to be driving at night.
- For both genders, vision plays a significant role in the self-restriction decision.
- A higher percentage of men than women continue to drive at night with poor vision.
- Men's night-driving cessation was associated with contrast sensitivity and depression, whereas women's night-driving cessation was associated with low-contrast acuity in glare as well as age.

Format: Html	Cost: Priced
Themes:	Eyesight and Driving, Fitness to Drive

Title:	**Colour vision**
Author:	NHS Choices website
Published:	NHS Choices website, no date
Link:	http://www.nhs.uk/conditions/Colour-vision-deficiency/Pages/Introduction.aspx
Objectives:	To provide information about colour vision.
Methodology:	N/A

Key Findings:

- People with colour vision deficiency are unable to see colours clearly and accurately, and may find it difficult to distinguish between different colours.
- Although often called colour blindness, true colour blindness, where no colour can be seen at all, is rare.
- People with colour vision deficiency may have difficulty identifying pale colours or deep colours if the lighting is poor.
- Colour vision deficiency can vary in severity. Some people are unaware they have a colour deficiency until they have a colour vision test. Others will experience a very slight difference in the way they appreciate different hues and shades of colour.
- In rare cases, a person may experience many colours that all appear to be the same.
- There are two main types of colour vision deficiency:
    - red-green deficiency – where people are unable to distinguish certain shades of red and green; it is the most commonly inherited type
    - blue-yellow deficiency – is a rare condition where it is difficult to distinguish between blue and green, and yellow may appear as a pale grey or purple
- There is currently no cure for inherited colour vision deficiency because it is not possible to repair or replace the cone cells in the retina. However, colour vision deficiency does not cause any long-term health problems.
- Most people with colour vision deficiency learn to adapt to their condition, and it is usually possible to find ways to compensate for difficulty with colours. For example, it is possible to recognise the position of the lights on a traffic light, rather than the different colours.

Format: Pdf	Cost: Free
Themes:	Eyesight and Driving, Fitness to Drive

<table>
<tr><td>Title:</td><td>What is colour blindness?</td></tr>
<tr><td>Author:</td><td>Colourblindawareness.org</td></tr>
<tr><td>Published:</td><td>Colourblindawareness.org, no date</td></tr>
<tr><td>Link:</td><td>http://www.colourblindawareness.org/colour-blindness/</td></tr>
<tr><td>Objectives:</td><td>To raise awareness about colour vision deficiency and to provide advice to people with the condition.</td></tr>
<tr><td>Methodology:</td><td>N/A</td></tr>
<tr><td colspan="2">Key Findings:
• Globally, colour deficiency affects approximately 1 in 12 men (8%) and 1 in 200 women.
• In Britain, this means that there are approximately 2.7 million colour blind people (about 4.5% of the entire population), most of whom are male.</td></tr>
<tr><td>Format: Pdf</td><td>Cost: Free</td></tr>
<tr><td>Themes:</td><td>Eyesight and Driving, Fitness to Drive</td></tr>
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<tr><td>Title:</td><td>Traffic signal colour recognition is a problem for both protan and deutan colour vision deficients</td></tr>
<tr><td>Author:</td><td>Atchison, David A., Pederson, Carol A., Dain, Stephen J., & Wood, Joanne M</td></tr>
<tr><td>Published:</td><td>Human Factors, 45(3), 2003</td></tr>
<tr><td>Link:</td><td>http://eprints.qut.edu.au/5462/</td></tr>
<tr><td>Objectives:</td><td>To investigate the effect of colour-vision deficiency on reaction times and accuracy of identification of traffic light signals</td></tr>
<tr><td>Methodology:</td><td>Participants were 20 colour-normal and 49 colour-deficient males, the latter divided into subgroups of different severity and type. Participants performed a tracking task. At random intervals, simulated standard traffic light signals were presented against a white background at 5° to right or left. Participants identified stimulus colour (red/yellow/green) by pressing an appropriate response button.</td></tr>
<tr><td colspan="2">Key Findings:
• Mean response times for colour normals were 525, 410, and 450 ms for red, yellow, and green lights, respectively.
• For colour deficients, response times to red lights increased with increase in severity of colour deficiency, with deutans performing worse than protans of similar severity: response times of deuteranopes and protanopes were 53% and 35% longer than those of colour normals.
• A similar pattern occurred for yellow lights, with deuteranopes and protanopes having increased times of 85% and 53% respectively.
• For green lights, response times of all groups were similar.
• Error rates showed patterns similar to those of response times.
• Contrary to previous studies, deutans performed much worse than protans of similar severity.
• Actual or potential applications of this research include traffic signal design and driver licensing.</td></tr>
<tr><td>Format: Pdf</td><td>Cost: Priced</td></tr>
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<tr><td>Title:</td><td>Reliability of Snellen charts for testing visual acuity for driving: prospective study and postal questionnaire</td></tr>
<tr><td>Author:</td><td>Z Currie, A Bhan and I Pepper</td></tr>
<tr><td>Published:</td><td>British Medical Journal; 321: 2000</td></tr>
<tr><td>Link:</td><td>http://www.bmj.com/content/321/7267/990</td></tr>
<tr><td>Objectives:</td><td>To determine what percentage of patients with 6/9 and with 6/12 vision could pass a number plate test. To assess the advice given by healthcare professionals.</td></tr>
<tr><td>Methodology:</td><td>Prospective study of 50 Ophthalmology outpatients with 6/9 vision and 50 with 6/12 vision in Sheffield and postal questionnaire to 100 general practitioners, 100 optometrists or opticians, and 100 ophthalmologists. The patients comprised 21 men and 29 women, aged 18 to 95 years. The main outcome measure was the ability to read a number plate at 20.5 m and health professionals' advice about driving on the basis of visual acuity.</td></tr>
<tr><td colspan="2">Key Findings:
• 26% of patients with 6/9 vision failed the number plate test.
• 34% of patients with 6/12 vision passed the number plate test.
• Of the GPs advising patients with 6/9 vision, 76% said the patients could drive, 13% said they should not drive, and 11% were unsure
• Of the GPs advising patients with 6/12 vision, 21% said the patients could drive, 54% said they should not drive, and 25% were unsure.
• The level of acuity at which optometrists, opticians, and ophthalmologists would advise drivers against driving ranged from $6/9^{-2}$ (ability to read all except two letters on the 6/9 line of the Snellen chart) to less than 6/18
• Snellen acuity is a poor predictor of an individual's ability to meet the required visual standard for driving.
• Patients with 6/9 vision or less should be warned that they may fail to meet this standard, but those with 6/12 vision should not be assumed to be below the standard.</td></tr>
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<table>
<tr><td>Title:</td><td>Measures of visual function and time to driving cessation in older adults</td></tr>
<tr><td>Author:</td><td>Freeman EE, Munoz B, Turano KA and West SK</td></tr>
<tr><td>Published:</td><td>Optom. Vis. Sci.; 82(8), 2005</td></tr>
<tr><td>Link:</td><td>http://trid.trb.org/view.aspx?id=782582</td></tr>
<tr><td>Objectives:</td><td>To identify the types of visual function loss that lead to driving cessation in order to better understand the relationship between vision and driving.</td></tr>
<tr><td>Methodology:</td><td>Data from the Salisbury Eye Evaluation project (a cohort study of 2,520 older adults followed for 8 years with data collected every two years) was analysed.</td></tr>
<tr><td colspan="2">Key Findings:
Those with worse baseline scores in acuity, contrast sensitivity, central or lower peripheral visual fields were more likely to stop driving.
Those who experienced 2-year losses in acuity, contrast sensitivity, or lower peripheral visual fields were more likely to stop driving.
With the vision variables entered into the same model, baseline acuity and 2-year acuity loss were no longer statistically significant.
Those with worse baseline scores in contrast sensitivity, central and lower peripheral visual fields were more likely to stop driving
Those who had 2-year losses in contrast sensitivity and lower peripheral visual fields were more likely to stop driving.
Interactions with gender, other drivers in the house, or cognitive impairment were not detected.
Older adults with worse scores in multiple measures of vision are more likely to stop driving and contrast sensitivity and visual fields are most associated with driving cessation.
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