Chapter 3: Vision

Introduction

Visual standards for drivers cannot be evidence-based since the scientific evidence to support them does not exist. Although everyone agrees that vision is essential to driving, there is no consensus on the minimum level of vision necessary for safe driving. In fact, as in other fields, some individuals are able to demonstrate safe driving abilites despite severely limited vision. However, there is consensus that corrected visual acuity should be 20/100 (6/30) or better and that drivers who do not meet the jurisdiction's standard should be afforded the opportunity to demonstrate safe driving despite their legal unfitness.

Visual Acuity Impairment

Visual acuity[5] refers to the spatial resolving ability of the visual system. In other words, it refers to the smallest size detail that a person can see. It is typically measured by asking a person to read a letter chart from a certain pre-specified distance where the top of the chart has big letters, and as one moves down to succeeding rows on the chart, the letters are smaller in size. It should be tested with both eyes open and examined together. Impairments in visual acuity can result from a number of different eye and neurological[32] conditions. These conditions include but are not limited to the following: macular degeneration[92], cataract[93], optic neuritis[94], end-stage glaucoma[95], retinal degenerations (e.g., retinitis pigmentosa[96], Stargardt disease[97]), diabetic retinopathy[98], optic atrophy[99], brain injury (e.g., stroke[23], trauma, tumor), diseases of the cornea[100], amblyopia[101], and uncorrected refractive error[102] (e.g., uncorrected myopia[103]).

Review of Evidence on Driver Safety and Performance With Respect to Visual Acuity Impairment:

Driver Safety: Many studies over the years have examined the association between visual acuity and incident crash involvement or a history of crash involvement. These studies are so numerous that they cannot all be listed below, so just a few citations are provided [1-5]. The overriding conclusion that can be drawn from this body of work is that visual acuity has not been related to crash involvement, or at best, is very weakly related to crash involvement. Thus, based on the available evidence, it has not been established that visual acuity testing is a useful screening test to identify drivers at high risk for crash involvement. However, there are important reasons, as discussed below, that support the continued use of visual acuity screening of applicants for driver licensure.

Driver Safety Continued:
It is important to keep in mind the difficulties encountered in examining the relationship between visual acuity and crash involvement in research. People with severely impaired visual acuity (e.g., worse than 20/100) are less likely to be drivers, and thus they are less likely to be in study samples evaluating this relationship. They are less likely to be drivers for two reasons – first, many jurisdictions have vision re-screening policies where people who have acuity worse than a certain level are not granted a license, and second, many people with severely impaired visual acuity voluntarily give up driving or drastically reduce the amount of driving they do. Thus, it is difficult to evaluate the safety records of drivers with severe visual acuity impairment if there are small numbers of these individuals on the road.

Many but not all States have vision re-screening policies where re-licensure applicants undergo a visual acuity[5] screening test when they apply for renewal of the license. The exact details of these policies vary among States, such as the number of years the renewal applies to, and whether all drivers undergo acuity re-screening at renewal, or only those who fall into certain age groups. Research has evaluated the impact of vision re-screening policies, particularly as they affect fatality rates in older drivers [6-9]. This research suggests that these policies are associated with a reduction in fatalities, although one must be cautious in interpreting the results of these studies since it is unknown exactly what it is about the policy that is associated with the fatality rate reduction (e.g., the visual acuity screening test itself, requiring older drivers to go to the licensing office for re-evaluation, or other aspects of the license renewal policy).

It is also important to point out that there is a growing consensus among those serving on medical advisory boards and researchers alike that visual acuity down to a level of approximately 20/70 - 20/100 is probably not a threat to safe driving. This growing consensus stems from two factors. First, as mentioned above, there is no evidence that people with acuity down to 20/100 are unsafe drivers. And second, an increasing number of jurisdictions are allowing people with visual acuity as low as 20/100 to be licensed if these people can demonstrate driving fitness in an on-road performance evaluation by a driving specialist.

Driver Performance:
Visual acuity is associated with highway sign legibility in that those with impaired visual acuity are more likely to make errors in identifying signs at a distance [10]. This is not surprising since engineers and highway departments select a font size for signs so that the sign can be effectively read at appropriate braking distances by people who have at least 20/30 or 20/40 acuity or better [11]. Thus people with visual acuity worse than this level are likely to experience difficulty reading highway signs and street name signs. The design of other aspects of the roadway environment (e.g., lane markings on the pavement) is also predicated on 20/30 – 20/40 acuity and thus the effectiveness of these measures on driver performance is practically linked to the driver's visual acuity level.

Reference Number	Complete Citation (With Quality of Evidence)
1	Rubin, G. S., et al., (2007). A Prospective, Population-Based Study of the Role of Visual Impairment in Motor Vehicle Crashes Among Older Drivers: The SEE Study. Investigative Ophthalmology & Visual Science; 48:1483-1491. [moderate]
2	Owsley, C., et al., (1998). Visual Processing Impairment and Risk of Motor Vehicle Crash Among Old Adults. JAMA, 279:1083-1088. [moderate]
3	Hills, B. L., & Burg, A. (1977). A Reanalysis of California Driver Vision Data: General Findings. Report N. LR 768. Crowthorne, Berkshire, UK: Transport and Road Research Laboratories. [moderate]
4	Decina, L. E., & Staplin, L. (1993). Retrospective Evaluation of Alternative Vision Screening Criteria For Older and Younger Drivers. Accident Analysis & Prevention; 25:267-275. [moderate]
5	Gresset, J., & Meyer, F. (1994). Risk of Automobile Accidents Among Elderly Drivers With Impairments or Chronic Diseases. Canadian Journal of Public Health, 85:282-285. [moderate]
6	Shipp, M. D. (1998). Potential Human and Economic Cost-Savings Attributable to Vision Testing Policies for Driver License Renewal, 1989-1991. Optometry and Vision Science, 75:103-118. [moderate]
7	Levy, D. T., et al., (1995). Relationship Between Driver's License Renewal Policies and Fatal Crashes Involving Drivers 70 Years or Older. JAMA, 274:1026-1030. [moderate]
8	Grabowski, D. C., et al., (2004). Elderly Licensure Laws and Motor Vehicle Fatalities. JAMA, 29:2840-2846. [moderate]
9	McGwin Jr., G., et al., (2008). The Impact of a Vision Screening Law on Older Driver Fatality Rates. Archives of Ophthalmology, 126:1544-1547. [moderate]
10	Higgins, K. E., et al., (1998). Vision and Driving: Selective Effect of Optical Blur on Different Driving Tasks. Human Factors, 2:224-232. [moderate]
11	Schieber, F. (2004). Highway Research to Enhance Safety and Mobility of Older Road Users. In: Transportation in an Aging Society: A Decade of Experience. Washington, DC: Transportation Research Board, pp. 125-154. [overview]

Other Considerations:

When a driver is identified who does not meet the visual acuity[5] standard for licensure, it is appropriate for the DMV to suggest that the driver seek a comprehensive eye examination from an ophthalmologist or optometrist (in case they have not had one recently). In some cases, the reduced visual acuity might be improved with appropriate treatment (e.g., corrective lenses, cataract[93] surgery). Since visual acuity impairment often has a very gradual onset, particularly in older adults, the person may not be aware that vision has declined.

Some jurisdictions allow for the use of the bioptic telescope[104] by drivers with visual acuity impairment, and among these jurisdictions, there is wide variability in the eligibility criteria for bioptic driving. It is important to note that there is no clear evidence either supporting or opposing the safety of bioptic driving. A few studies have been carried out but they are methodologically flawed and do not resolve this issue.

Although visual acuity has never been shown to be a good screening test for identifying drivers at high-risk for future crash involvement, a visual screening test used at licensing offices does ensure that a driver meets some minimum level of vision. The critical importance of the acuity test fulfilling this function at licensing offices cannot be ignored or denied; the public wants and deserves a government agency that has some method for not

allowing the licensure of people with serious vision impairment. However, the issue then becomes what should the cut point be for pass versus fail on the visual acuity screening test. As discussed above, the research does not tell us what this cut point should be. Some jurisdictions allow drivers with visual acuity down to 20/100 to drive if they can demonstrate driving fitness in an on-road test by a driving specialist. It is recommended that these jurisdictions evaluate the safety (i.e., crash involvement) of these drivers over time and compare them to drivers who do pass the visual acuity screening test that the jurisdiction administers. This would be very helpful information for jurisdictions that are considering the wisdom of extending licensure of applicant with visual acuity as low as 20/100.

Recommendation:

One of the following will be checked.

☐ Evidence is relatively clear and allows for a recommendation.

☒ Evidence is not so clear cut but is suggestive and allows for a guidance statement.

☐ Evidence is either highly inconclusive or non-existent and does not suggest a specific driver licensing action.

Recommendation or Guidance Statement:

The use of a visual acuity[5] screening test at licensure and re-licensure ensures that a driver meets a jurisdiction's vision standard at the moment of licensure or re-licensure. Driving is inarguably a highly visual task, and thus visual acuity screening is an important step jurisdictions take to prevent people with serious impairment in their central vision from becoming licensed. A positive impact of visual acuity screening is that it ensures that signs and other critical markings in the roadway environment (lane markings) will be adequately legible to most drivers.

Driver re-screening policies that include a visual acuity screening test have been shown to reduce the fatality rate of older drivers, but it is important to recognize that it remains to be determined what it is about re-screening policies that makes them effective in reducing fatality rates. An important advantage that visual acuity screening for licensure or re-licensure offers is that it provides feedback to drivers who fail the screening test that they may need a comprehensive eye examination that might lead to treatments to improve their vision.

There are several benefits to visual acuity screening at licensure. However, it is important to recognize that visual acuity is unrelated to or only weakly related to future driver safety (i.e., crash involvement). Thus, visual acuity testing by itself is not an effective way to screen for drivers at high risk for crash involvement. Other visual factors (discussed in other sections) are much more important in understanding crash risk, particularly in older drivers, than is visual acuity.

It is difficult to suggest the appropriate pass-versus-fail cut-off that should be used for visual acuity screening. The research to date does not provide an answer to the "cut-point" problem. However, there is an important opportunity going forward that might go far in addressing this question. Specifically, some jurisdictions are allowing applicants with visual acuity down to 20/100 to drive if they can demonstrate safe driving skills in an on-road evaluation conducted by a driving specialist. Comparison of the motor vehicle collision rate of these drivers to that of drivers who pass the visual acuity screening test could be very informative as to the safety impact of such a policy.

Chapter 3: Vision

Visual Field Impairment

The visual field[6] refers to one's entire spatial area of vision when fixation is stable, and includes both central[108] and peripheral vision[109]. The size of the visual field is defined in terms of a "visual angle." For an adult with normal vision, when both eyes are open, the visual field extends horizontally about 180 to 200 degrees of visual angle and vertically about 100 degrees. For each eye individually, the horizontal field is about 160 degrees. The visual field of one eye overlaps with that of the other eye to a very large degree, although not totally. The visual field is typically evaluated using a device called a perimeter or a tangent screen. Visual fields should be tested with both eyes open and examined together. Impairment in the visual field can result from a number of different eye and neurological[32] conditions including but not limited to glaucoma[95], optic neuritis[94], diabetic retinopathy[98], brain injury (e.g., stroke, trauma, tumor), retinal degenerations (e.g., retinitis pigmentosa[96]), and eye trauma.

Review of Evidence on Driver Safety and Performance With Respect to Visual Field Impairment:

Driver Safety: The research literature on visual field impairment[110] and driver safety does not provide a clear answer as to what types of visual field impairment and what degree of visual field impairment is a threat to safe driving. What literature on this topic does exist provides some general information, but little in the way of specific data that could serve as a basis for recommendations or guidance. Visual field impairment appears to elevate crash risk when it is serious (covers a great deal of the visual field with severe light sensitivity loss) and when it is binocular (i.e., occurs in both eyes) [1-4]. However, what is unknown is how spatially extensive the visual defects must be, and how severe the light sensitivity deficits must be, before safe driving is threatened. In addition, it remains unknown to what extent drivers with severe visual field impairment can compensate for their field impairment through scanning eye and head movements. If field loss is in only one eye, driver safety does not appear to be affected [1].

Driver Performance: A study on simulated binocular visual field loss and driving performance on a closed course showed that when the diameter of the visual field was reduced to 40 degrees or 20 degrees, drivers showed decrements in their ability to identify road signs, avoid obstacles, and maneuver through limited spaces, with the 20-degree field causing more severe decrements than the 40-degree field [5]. In another study, most drivers with moderate binocular visual field loss (i.e., horizontal field ranging from 78 to 165 degrees) displayed acceptable on-road driving skills [6], although another study showed that some had problems with peripheral obstacle detection [7]. Given that there are so few studies on driving performance and visual field impairment, it is difficult to make any conclusions about the driving capabilities of people with various types of field loss and various degrees of impairment.

Reference Number	Complete Citation (With Quality of Evidence)
1	Johnson, C. A., & Keltner, J. L. (1983). Incidence of Visual Field Loss in 20,000 Eyes and its Relationship to Driving Performance. Archives of Ophthalmology, 101:371-375. [moderate]
2	McGwin Jr., G. et al., (2005). Visual Field Defects and the Risk of Motor Vehicle Collisions Among Patients With Glaucoma. Investigative Ophthalmology & Visual Science, 46:4437-4441. [moderate]
3	Haymes, S. A., et al., (2007). Risk of Falls and Motor Vehicle Collisions in Glaucoma. Investigative Ophthalmology & Visual Science, 48:1149-1155. [moderate]
4	Rubin, G. S. et al., (2007). A Prospective, Population-Based Study of the Role of Visual Impairment in Motor Vehicle Crashes Among Older Drivers: The SEE Study. Investigative Ophthalmology & Visual Science . 48:1483-1491. [moderate]
5	Wood, J. M., & Troutbeck, R. (1992). Effect of Restriction of the Binocular Visual Field on Driving Performance. Ophthalmic & Physiological Optics, 12:291-298. [moderate]
6	Bowers, A., et al., (2005). On-Road Driving with Moderate Visual Field Loss. Optometry & Vision Science, 82:657-667. [moderate]
7	Haymes, S. A., et al., (2008). Glaucoma and On-Road Driving Performance. Investigative Ophthalmology and Visual Science, 49:3035-3041. [moderate]

Other Considerations:

As mentioned above, there is a paucity of information from the research literature as to the safety of drivers with visual field[6] impairment. Given this situation, a fair approach when considering the appropriateness of licensure of a driver with visual field impairment[110] might be to have a driving specialist evaluate the driving skills of the individual under a variety of on-road driving situations. Based on this information (and any other information required by the jurisdiction), the jurisdiction and its medical review staff could then make a decision about licensure.

Recommendation:

One of the following will be checked.

☐ Evidence is relatively clear and allows for a recommendation.

☐ Evidence is not so clear cut but is suggestive and allows for a guidance statement.

☒ Evidence is either highly inconclusive or non-existent and does not suggest a specific driver licensing action.

Recommendation or Guidance Statement:

Given that there is a shortage of information on the safety of drivers with visual field impairment, the only recommendation that can be made is that which is stated in the section on "Other Considerations." One approach when considering the appropriateness of licensure of a driver with visual field impairment might be to have a driving specialist evaluate the driving skills of the individual under a variety of on-road driving situations.

Recommendation or Guidance Statement Continued:

Using this information (and any other information required by the jurisdiction), the jurisdiction and its Medical Advisory Board could then make a decision about licensure on a case-by-case basis.

Chapter 3: Vision

Hemianopia

Homonymous hemianopia[113] is a visual field impairment[110] where complete or near complete loss of light sensitivity occurs in one half of the visual field[6] on the same side in visual space. In other words, when the person with hemianopia gazes straight ahead, one half of the person's visual world, either on the right or left, is largely absent. Hemianopia can be confirmed by an ophthalmologist, neurologist, or optometrist using a visual field test. It is caused by damage to the visual pathway due to a brain injury, the most common causes being stroke[23], trauma, or tumor. A related condition is called quadrantanopia[116], in which there is a loss of sensitivity in one-quarter (or one quadrant) of the visual field. It is also caused by brain injury.

Review of Evidence on Driver Safety and Performance With Respect to Hemianopia

Driver Safety:
There are no previous studies that have examined the relationship between hemianopia and crash involvement.

Driver Performance:
A few studies have examined driving performance in people with hemianopia, either on-road driving or performance in a driving simulator [1-4]. Results suggested some but not all drivers exhibited problems with on-road steering steadiness and vehicle control skills. However, some drivers with hemianopia or quadrantanopia who were evaluated on-road displayed driving skills that were indistinguishable from people who had normal visual fields and were rated as safe drivers by the driving specialist.

Reference Number	Compete Citation (With Quality of Evidence)
1	Szlyk, J. P., et al., (1993). Effects of Age and Hemianopic Visual Field Loss on Driving. Optometry & Vision Science, 70:1031-1037.
2	Tant, M. L. M., et al., (2002). Driving and Visuospatial Performance in People with Hemianopia. Neuropsychological Rehabilitation, 12:419-437.
3	Racette, L., & Casson, E. J. (2005). The Impact of Visual Field Loss on Driving Performance: Evidence From On-Road Driving Assessments. Optometry & Vision Science, 82:668-674.
4	Wood, J. M., et al., On-Road Driving Performance by Persons With Hemianopia and Quadrantanopia. Invest Ophthalmol Vis Sci., 50(2):577-85. [moderate]

Other Considerations:
Several studies on hemianopia[115] and driving performance have methodological limitations that preclude their being generalized to people with hemianopia at large. Some of these problems include study samples that are small, a focus on drivers who were known to have

driving problems even before they are evaluated, and drivers who are only two months from the time of their brain injury so are they still in the process of recovering. Recent work has demonstrated that some drivers with hemianopia can display safe driving skills and drive in a manner that cannot be differentiated from the driving of people with normal visual fields[6]. The fairest approach may be to allow license applicants with hemianopia to be evaluated by a driving specialist before determining the suitability of licensure. Currently, many jurisdictions categorically deny people with hemianopia licensure on the basis of the jurisdiction's visual field requirement, without ever evaluating the person's actual driving performance.

Recommendation:

One of the following will be checked.

☐ Evidence is relatively clear and allows for a recommendation.

☒ Evidence is not so clear cut but is suggestive and allows for a guidance statement.

☐ Evidence is either highly inconclusive or non-existent and does not suggest a specific driver licensing action.

Recommendation or Guidance Statement:

Drivers with hemianopia or quadrantanopia[116] should be given the opportunity for a comprehensive on-road evaluation by a driving specialist, and if judged fit to drive, should be given the opportunity to take the jurisdiction's road test. Given the wide individual variability in driving skills of people with hemianopia, it could be viewed as unfair for jurisdictions to categorically deny licensure to people with hemianopia or quadrantanopia without the opportunity for them to demonstrate safe driving skills.