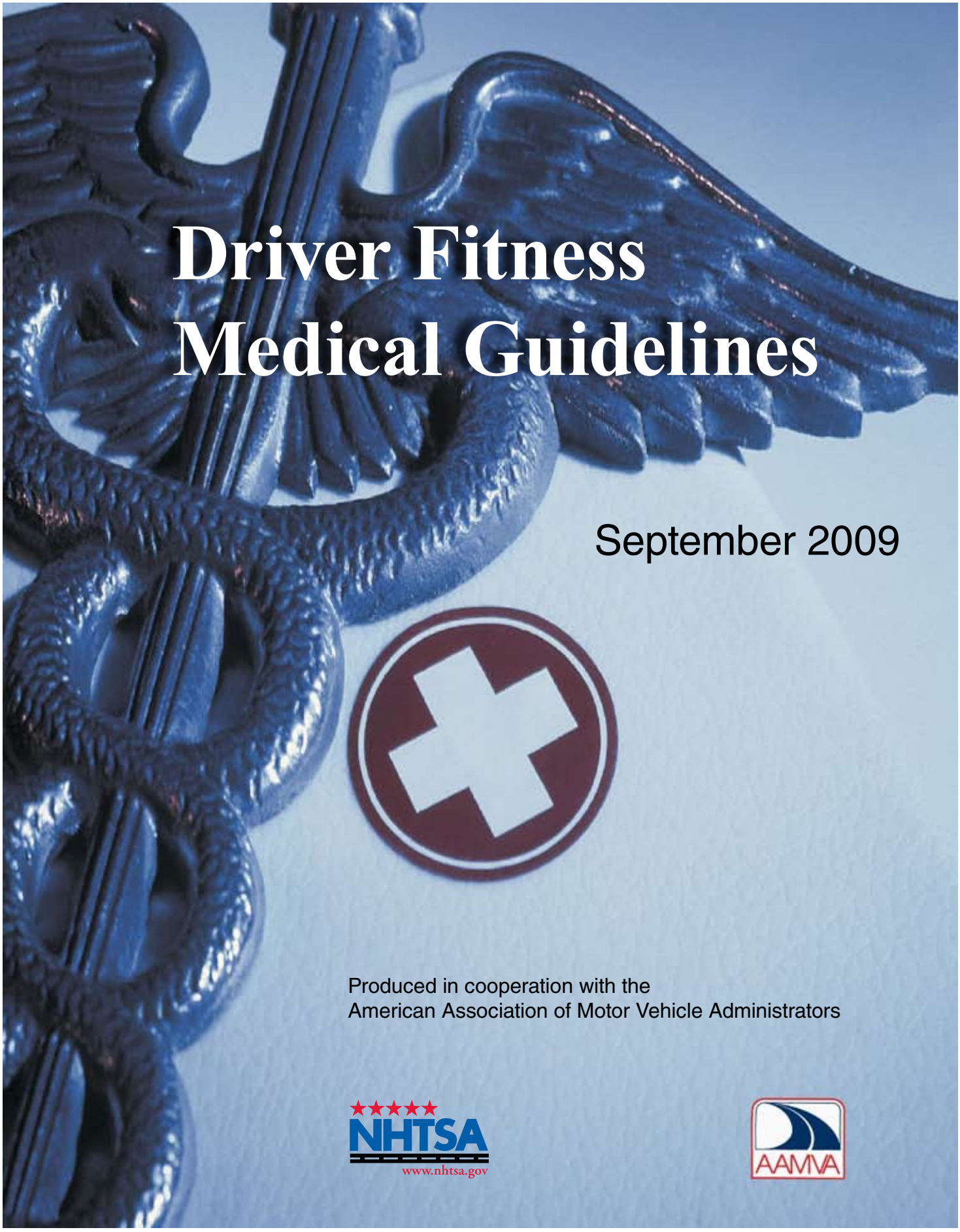

Driver Fitness Medical Guidelines

September 2009

Produced in cooperation with the
American Association of Motor Vehicle Administrators

NHTSA
www.nhtsa.gov

AAMVA

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Foreword

This guide provides guidance to assist licensing agencies in making decisions about an individual's fitness for driving. This is the first attempt to produce a consolidated document covering medical conditions included in the task agreement between the National Highway Traffic Safety Administration (NHTSA[1]) and the American Association of Motor Vehicle Administrators (AAMVA[2]). Many medical conditions are not covered by this document. They have been excluded in order to limit the project to manageable objectives and to focus on the most common conditions. Additional conditions will be addressed in subsequent projects. Evaluations of driver fitness should not be limited to only those medical conditions that are addressed in this guide. A broad-spectrum approach is best when addressing driver fitness. Individual evaluations should assess vision, physical impairments, and medical conditions such as diabetes, dementia, sleep apnea, and seizures. Temporary medical conditions should also be assessed.

These guidelines are voluntary. They are provided to assist motor vehicle administrations in making the difficult decisions that weigh an individual's driving privilege against the demands of public safety. Establishing medical guidelines that are applicable for all jurisdictions has been challenging. This guide was not created to determine the methods by which jurisdictions should make these decisions. Whether to use medical advisory boards, administrative review, or a combination of these should be determined within each jurisdiction. Although these guidelines are based upon a scientific literature review and provide general recommendations, decisions concerning a driver's ability should be made on a case-by-case basis.

It is understood that drivers should be allowed to continue to drive as long as possible provided there is a reasonable expectation that they can safely operate a vehicle. Only when an individual poses an imminent threat to public safety should their driving privilege be withdrawn or restricted. The driving privilege may be restored when the individual's condition becomes stable or returns to a state where their mental and physical capability allows them to operate a vehicle safely. An individual's having a disease is not sufficient cause for a jurisdiction to withdraw the driving privilege. The disease must affect that person visually, physically, or cognitively in a manner that jeopardizes public safety. These medical guidelines are based upon research and a best practices approach toward determining whether an individual is capable of driving safely.

However, when making decisions about an individual's fitness for driving, it is important that licensing agencies comply with the Americans with Disabilities Act (ADA), a Federal civil rights law that provides comprehensive protection for disabled individuals. Federal ADA regulations explicitly forbid driver licensing agencies from administering their programs in a manner that subjects qualified individuals with disabilities to discrimination on the basis of disability. Except with respect to a limited number of functional deficits about which there is consensus in the medical and highway safety communities (for example, the need for an applicant to be seizure-free for a period of time prior to licensing), States may not use inflexible medical standards to exclude disabled applicants from their licensing programs. Rather, the ADA requires that States

individually assess an applicant's fitness to drive, as through the review of medical documentation or the performance of written or on-road driving examinations. The guidelines in this document should help licensing authorities to make appropriate licensing decisions that are compliant with these civil rights requirements.

The AAMVA Driver Fitness Working Group (DFWG[3]) was composed of jurisdictional representatives. The DFWG served as the sounding board and provided important direction for the development of these guidelines for making licensing decisions on medically at-risk drivers. Participants of the DFWG included:

- Kim Snook, Iowa Motor Vehicle Division, Chair;
- Mike Alderman, Florida Division of Driver Licenses;
- Michael Bailey, Oklahoma Department of Public Safety;
- Rhonda Craft, California Department of Motor Vehicles;
- Cydney DeModica, Arizona Motor Vehicle Division;
- Jamie Dow M.D., Société de l'assurance automobile du Québec ;
- Cheryl Forehand, R.N., Maryland Motor Vehicle Administration;
- Jack Joyce, J.D., Maryland Motor Vehicle Administration;
- Jennifer Kroeker-Hall, Driver Licensing Policy Insurance Corporation of British Columbia;
- Jean G. LeBlanc, New Brunswick Department of Transport;
- Diana McIntosh-Dilworth, Indiana Bureau of Motor Vehicles;
- William Merrill, Oregon Driver and Motor Vehicle Services;
- Jill Reeve, Wisconsin Bureau of Driver Services;
- Selma Sauls, Florida Division of Driver Licenses;
- Susan Stewart, North Carolina Division of Motor Vehicles;
- Carl Soderstrom M.D., Maryland Motor Vehicle Administration;
- Cynthia Owsley, Ph.D., M.P.S.H., University of Alabama at Birmingham;
- Mathew Rizzo M.D., University of Iowa; and
- Wendy Stav, Ph.D., Towson University.

This document is the result of a great deal of research. The DFWG's mission was to establish guidelines that jurisdictions can use to apply a scientific, evidence-based approach to their licensing decisions. Throughout the development of this document, the DFWG sought input from stakeholders through meetings and open lines of communication. The DFWG considered each recommendation and issue raised by individuals within the stakeholder community in developing these guidelines. Every effort was made to accommodate those recommendations. Recommendations that could not be supported by outside evidence were not included. There are, however, several cases where there is a legitimate difference in opinion between the DFWG and stakeholders in how the outside evidence could be interpreted in the formulation of guidance to the driver licensing administrator. By recognizing these differences in opinion, our intent is to provide decision-makers with a better understanding of and respect for potentially-dissenting points of view. The guidelines are designed to provide

evidence-based support to the driver licensing community in order to enhance highway safety and protect public health.

All stakeholders should continue an active involvement in bringing new evidence to the attention of AAMVA, NHTSA, and the licensing community to enhance revisions of this document. This document will be updated as research and data becomes available from the medical and motor vehicle communities.

To submit comments to AAMVA, please forward comments to:

AAMVA
Program Director, Programs Division
4301 Wilson, Blvd., Suite 400
Arlington, VA 22203

Questions or comments regarding NHTSA's involvement in the development of this guide should be forwarded to:

NHTSA
Chief, Safety Countermeasures Division
1200 New Jersey Avenue SE.
Washington, DC 20590

How to Use the Guide

In the guide, there are ratings of the quality of the evidence: high, moderate, and low. These ratings represent the replicability of the research presented in each study. A "low" rating for a study does not mean that the research was poorly conducted; it suggests that there are limits to its application in real-world settings. A group of studies with low ratings is more meaningful than a single, similarly-rated, study. Much of the research that was uncovered in the development of these guidelines falls into the low to moderate replicability. The volume of research in any particular area, combined with the quality of evidence, contributes to the strength of the guidance that is offered to the driver licensing authority.

Chapter 1 contains key guidance for driver licensing authorities, medical providers, and drivers. Because the primary audience for this guide is driver licensing authorities, the guidance for the other audiences should be used to educate these important referral sources on how to keep drivers safe.

Chapters 2 through 5 contain background information, detailed recommendations, and guidance for a range of the most commonly reviewed medical conditions that drivers present to licensing authorities. Guidance is provided, based on the quality of the evidence, in one of the three following categories:

1. Evidence is relatively clear and allows for a recommendation.
2. Evidence is not so clear-cut but is suggestive and allows for a guidance statement.
3. Evidence is either highly inconclusive or nonexistent and does not suggest a specific driver licensing action.

Appendix B contains a sample medical examination form that aims to help the driver licensing authority to collect useful and complete information so it may make an informed decision regarding the licesensure of an individual driver. This form reflects the guidance on soliciting information that is included in the body of the guide.

When reading this guide you will see numbers just above important or frequently used key words. These numbers correspond to the definition or acronym of the word that can be found in the glossary on page 136. Some numbers appear more than once, since some words appear in several chapters.

Chapter 1: Recommendations for DMVs, Clinicians, and Drivers

Introduction

Balancing public safety and individual driving privileges has been a difficult challenge for driver licensing agencies. The need to establish policies for conducting initial medical assessments, evaluating drivers, and deciding what, if any, restrictions should be imposed on their driving privilege has left licensing agencies looking for reliable guidlines.

It must be emphasised that the Departments of Motor Vehicles (DMVs[4]) are tasked with determining whether or not individuals are functionally able to drive safely. The larger health aspects of these guidelines may be of interest to clinicians and researchers but are not an immediate concern for the DMV.

For instance, DMVs determine whether a driver's visual acuity[5] meets a prescribed standard. Generally, questions of how an individual's visual acuity is corrected, i.e., spectacles versus contact lenses, are not within the DMV's purview. It is up to drivers to ensure that they meet the visual acuity standards. If a driver's current prescription is not appropriate, it is not up to the DMV to ensure that it is changed. Drivers who are suspended can take steps to correct their visual acuity and request a retest. The DMV can then determine whether the individual's corrected vision meets the standard. If it does the license will be renewed. If not, the suspension will be reconfirmed.

It should also be noted that DMVs rely on medical forms to gather vision information on drivers, particularly with the growing popularity of remote permit renewals where drivers are not required to be physically present.

Medical Guidelines for DMVs

These recommended guidelines can be supported by scientific evidence:

Vision:

1. The DMV should test visual acuity at permit renewal for all drivers age 65 or older.

2. The DMV should test visual acuity with both eyes open and examined together.

3. 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.

4. States that permit drivers with relatively low vision to drive should 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.

5. The DMV should give drivers with visual field[6] defects that render them unfit according to the standards on visual fields the opportunity to demonstrate that they can drive safely despite their disability.

6. The DMV should test visual fields with both eyes open and examined together.

7. With regard to color vision the DMV should require that drivers be able to discriminate between the different traffic lights.

8. Since slowed visual processing speed has been repeatedly shown to be associated with driver safety and performance problems, jurisdictions should consider implementing a screening test for licensure and re-licensure that assesses processing speed.

Physical Limitations:

1. The DMV should define a physical limitation as the incapacity to perform any of the physical operations required to operate a standard (unmodified) motor vehicle of the class of vehicle that the driver wishes to operate.

2. The DMV should individually assess drivers with physical limitations regarding their ability to drive.

3. The DMV should conduct an assessment to evaluate an individual's ability to drive each class of vehicle included in the proposed permit. DMVs[4] may require adaptations or modifications to the vehicle and/or restrict driving to vehicles with automatic transmissions.

4. The DMV should clearly state that a driver's inability to safely operate a vehicle that has been modified to accommodate a driver's physical limitations is incompatible with driving and the license should be suspended.

5. In the case of degenerative disorders that affect physical function, such as Parkinson's Disease and multiple sclerosis, the DMV should evaluate the drivers, at a minimum using behind the wheel testing, on a periodic basis to ensure that they are capable of continued safe driving.

Dementia:

1. The DMV should note that severe dementia[7] is incompatible with safe driving.

2. The DMV should recognize that mild and moderate dementia may be compatible with safe driving. Individual functional assessment of driving skills is necessary to determine fitness to drive. Reassessment is required at 6- to 12-month intervals based on the evolution of the dementia.

3. There is insufficient evidence to recommend driver licensing countermeasures such as restricted driver licenses in drivers with dementia. There is concern among some experts that issueing restricted licenses to individuals with dementia may falsely give the impression that they are deemed safe to drive, when in fact they are deemed not safe without the restrictions.

4. "Co-piloting," or having another individual guide a driver with dementia through the driving task, is not a safe driving practice. DMVs should not issue restricted licenses that are contingent on a driver with dementia having a passenger to help them.

5. Indicators that DMVs can consider using to require a cognitive assessment by a health care professional include at least two* of the following:

   (1) Age 80 years or older;
   (2) History of a recent crash or moving violation;
   (3) Applicant self-report or caregiver report of impaired skills;
   (4) Use of psychoactive medications[8] such as benzodiazepines[9], neuroleptics[10], antidepressants[11], or use of medications for Alzheimer's disease[12] (AD[13]);
   (5) History of active alcohol abuse;
   (6) History of falls;
   (7) Inability to understand or hear instructions during interactions with the DMV[4] examiner or the health professional;
   (8) Scores with simple screening tools that indicate the possibility of a cognitive deficit; and
   (9) Inability to complete the DMV knowledge test.

   Applicants with greater numbers of risk factors should be considered at greater risk, although the relative risks are not necessarily additive.

Diabetes†:

1. The DMV should note that recurrent hypoglycemic[14] episodes requiring third-party assistance are incompatible with safe driving unless certification by the treating clinician demonstrates that the driver has been stable for three months.

2. The DMV should establish policies that following a hypoglycemic episode requiring third-party assistance, a driver should not resume driving unless the treating clinician has certified that the diabetes[15] is under control.

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* Whle the above recommendations came from the Driver Fitness Working Group, not all experts agree. Both the Alzheimer's Association and AARP disagreed with the presence of *only* two risk factors as justification for further assessment at the request of the DMV. For a better understanding of their reasons for non-concurrence, readers should contact those organizations.

† While the above recommendations came from the Driver Fitness Working Group, not all experts agree. Alternative viewpoints are presented in Appendix C.

3. The DMV should note that hypoglycemic unawareness is incompatible with safe driving.

4. The DMV should require periodic medical controls from drivers with diabetes who experience hypoglycemic episodes requiring the intervention of a third party. The frequency of these reports should be determined by the DMV.

Seizures:

1. A diagnosis or history of seizures should preclude unconditional certification by the DMV to drive.

2. The DMV should note that a driver who suffers a convulsive seizure caused by abuse of alcohol or drugs is unfit to drive until the driver can demonstrate a period of at least 6 months of abstinence.

3. The DMV should require periodic medical controls of drivers with epilepsy[16] at a frequency to be determined by the DMV[4].

4. The DMV should note that a driver who suffers a convulsive seizure[17] is considered unfit to drive for a period of at least 6 months following the incident. Resumption of driving should require a positive recommendation by the treating clinician.

5. A drivers with epilepsy who no longer require AEDs[31] and has not had a seizure for at least 2 years should no longer require annual medical recertification.

Sleep Disorders:

1. The DMV should note that a diagnosis of obstructive sleep apnea[18] (OSA[19]) is incompatible with safe driving if the driver manifests daytime drowsiness or has an apnea hypopnea index[20] (AHI)[21] of 20 or more unless treatment is demonstrated to have eliminated the daytime drowsiness or to have lowered the AHI to 19 or less. The DMV should establish policies such that maintenance of driving privileges is conditional upon the maintenance of the successful therapy and subject to periodic medical controls at a frequency to be established by the DMV.

2. The DMV should note that narcolepsy[22] is incompatible with safe driving unless successfully treated by a clinician or health care provider.

Medical Guidelines for Clinicians and Other Health Care Providers

Many of the recommendations by the researchers concern matters that are not in the purview of the DMV but are important considerations for the clinicians and other health care professionals who must evaluate driver medical fitness. The DMV should educate these professionals about the effects of functional impairments on safe driving, particularly in the context of medical controls.

In evaluating a driver's medical fitness, the health professional must consider a number of factors. Any medical condition that affects physical or mental functioning may affect driving fitness. When the physical or mental effects of the condition are progressive in nature, periodic evaluations are required. The presence of multiple medical conditions means that the cumulative effects of all the medical conditions must be evaluated.

Medical conditions that affect driving fall into three categories:

1. Conditions that engender functional limitations (chronic compromise);
2. Conditions that involve an associated risk of compromise of consciousness (acute compromise); and
3. Use of substances (alcohol, drugs, medications) judged to be incompatible with safe driving.

This classification is useful when dealing with questions of driver fitness. All the medical conditions that may affect driver fitness will fall into one of these categories. Unfortunately, it is impossible to draw up a comprehensive list of conditions that health professionals must consider in their evaluation of medical driving fitness. Any disease process that over time will affect sensory, motor, or cognitive ability can influence driving ability.

Driving cessation is an unfortunate fact of life. Everybody will cease driving one day if they live long enough. Men can expect to cease driving about 6 years before their death and for women the figure is about 11 years. Consequently, health professionals can expect to be confronted by mobility problems for their clientele as their patients age. The maintenance of mobility and the problems caused by the loss of driving privileges will become a major concern for most health-care providers in the near future. However, mobility concerns must take second place to road safety considerations when driver fitness is compromised.

Health professionals must always bear in mind that they do not withdraw or suspend driving privileges; only the DMV has the authority to do so. The health professional's role is to provide the DMV with the information it requires in order to make the appropriate decision about the driver's ability to drive safely in the light of the driver's state of health. Consequently, it is acceptable for health professionals to inform the DMV that they are unable to form a definite opinion about the driver's medical fitness to drive based upon their office evaluation since many instances will require a road test.

Some conditions or their treatment may have temporary effects on driving fitness. Temporary unfitness to drive is the purview of the treating clinician when the period of unfitness will be of short duration. The routine advice given to the patient in the normal course of managing the condition should always include driving considerations. However, if the patient indicates the intention to disregard this advice, the health professional should document the advice and the patent's stated intentions in the patient's file and inform the DMV of the potentially dangerous situation.

The following sections present a discussion of the considerations a health care professional should review when evaluating a driver's medical fitness to drive.

Vision:

1. Health care professionals should recognize that drivers of private automobiles and motorcycles require a visual acuity[5] and field of vision test according to the statutory requirements within their jurisdiction with both eyes open and examined together. Any visual condition that leads to a lowering of either corrected visual acuity or visual field[6] to levels inferior to the standard renders the driver unfit for driving without restrictions issued by the DMV.

2. Health care professionals should be aware that, should this occur, the driver who wishes to continue driving will be required to undergo a functional evaluation in order to determine if they are able to drive safely despite their failure to meet the standards. In order to succeed in the functional evaluation, the driver must demonstrate that their condition is stable and that they are able to compensate for the resulting disability. In the event that the driver's condition is unstable, or still evolving, the health professional should encourage the driver to wait for the condition to stabilize.

3. Health care professionals should be aware that changes in visual acuity or visual fields following stroke[23] or traumatic head injury[24] are often accompanied by changes in cognitive status. Consequently, the investigation of visual changes related to such events should always include evaluations of the speed of visual processing.

4. Health care professionals should be aware that although it is agreed that contrast sensitivity[25] is an important factor in the visual evaluation of a patient, the current state of the art does not permit its incorporation into the driver evaluation process.

5. Health care professionals should be aware that after the sudden loss of one eye, the patient will require a period of adaptation to monocular vision before resuming driving. The length of the period required can vary greatly from one individual to another and clinicians should advise their patients in this situation to cease driving until their evaluations confirm successful adaptation.

Physical Limitations:

1. Health care professionals should be aware that any condition that affects the upper or lower limbs, the neck, and the back may have an effect on the patient's fitness to drive. It is extremely rare that the driver's vehicle cannot be modified to accommodate a physical limitation. However, unless the appropriate evaluation of the driver's needs is performed, the driver may persist in driving a vehicle without modifications, thereby creating a situation that is potentially dangerous. The health care professional should make referrals to driving professionals for assessment and rehabilitation related to driving.

2. Health care professionals should be aware that in situations where there is an acute injury (fractures, dislocations) or a post-surgical situation, the functional limitations may be temporary. As long as the immobilization is in place or the affected articulation has not achieved full mobility the driver should be advised to refrain from driving. For example, attempting to drive using the unaffected left leg to operate the pedals, using a cane or other device to operate the pedals, or having a co-driver work the stick-shift are not safe alternatives to temporary driver cessation in this situation.

3. Health care professionals should be aware that the removal of an immobilization after several weeks of immobilization does not imply immediate fitness to resume driving. After a 3- to-4 week immobilization, an ankle may take up to 9 weeks before the ankle achieves full function. While this does not mean that the resumption of driving requires an additional 9 weeks, it does mean that resumption should only occur when the mobility of the articulation is adequate for driving rather than immediately following cast removal.

4. Health care professionals should be aware that immobilizations of the upper limbs, especially immobilizations of the wrist, hand, or fingers, may have an adverse effect upon the driver's ability to manipulate the controls and the steering wheel. Adaptive devices that are recommended by a driving professional could alleviate the person's vehicle control issues.

5. Health care professionals should be aware that when the loss of function is permanent, the impact upon driving will depend upon the extent of the loss of function. Minimal limitations, such as partial loss of one or several fingers or toes, may not require modification of the driver's vehicle because they have no effect on the physical functions required for driving.

6. The health care professional must assess the extent of the physical and psychomotor limitations and determine if further functional evaluation is indicated. Any doubts about the capacity of the driver to perform the tasks required for driving safely must be subjected to further assessment, usually by an occupational therapist or a driving specialist. In-office evaluation is rarely adequate.

7. Since every case must be evaluated on its individual merits, there are no generalized rules of the type "If you have X, you cannot drive for 3 weeks." Each case must be assessed taking into consideration the individual characteristics of the person involved.

Dementia:

1. Health care professionals should be aware that suspicion of the possibility of a diagnosis of dementia[7] should immediately trigger a functional evaluation of the driver's fitness to drive. Some experts suggest that any cognitive deficit, particularly a newly observed deficit, should also trigger a functional evaluation.

2. Health care professionals should be aware that although there is unanimous agreement that severe dementia is incompatible with safe driving, precluding the requirement for a functional evaluation, the cognitive deficiencies in mild and

moderate dementia are so varied that it is impossible to predict on-road driving performance on the basis of the results of the various tests used to evaluate cognitive deficits.

3. Health care professionals should be aware that self-awareness/insight and judgment are vital to safe driving but are difficult to measure in cognitive tests. Even when the off-road examiner can identify problems with insight and judgment it is not easy to predict driver performance. Consequently, except in the most extreme cases, which should probably be classified as severe rather than mild or moderate dementia, the road test is an integral part of the functional evaluation of driving skills.

4. Health care professionals should be aware that a number of tests have been identified as useful in predicting driver performance. Trail Making A and B[26] and similar tests are useful in identifying drivers who may perform badly on road tests. Their predictive power is not sufficient for licensing decisions to be based solely on the results of these and similar tests, but it is appropriate for identifying individuals for further examination.

5. Health care professionals should be aware that the Mini Mental Status Exam[27] (MMSE[28]) or Folstein test is a screening tool useful in identifying people with a cognitive problem that requires further assessment. Although it has some predictive value as far as on-road performance is concerned, it can not be used to exclude the person from holding a license.

6. Health care professionals should be aware that a score of 24/30 or less on the MMSE[28] equates to a 70-percent chance of failure on the road test and a score of 19/30 to a 95-percent failure rate. However, a score of 24 also equates to a 30-percent chance of success. No method has been developed to identify which group an individual will fall into. Consequently, an MMSE score, by itself, is insufficient to justify a recommendation of driving cessation.

7. Health care professionals should be aware that even a score of 30/30 on the MMSE does not preclude the chance of failure on the road test. Since the MMSE does not evaluate insight or judgment, deficiencies in these areas are possible with such a result.

8. The health-care professional who suspects a cognitive problem, no matter what the MMSE result, should insist upon a functional assessment. The same is true when the MMSE result is abnormal.

9. Ideally health care professionals would detect the potentially-compromised patient before there is a road-safety-related incident. Unfortunately, this is not always the case, partly because most health professionals have little knowledge of or awareness of the road safety implications of many medical conditions, including mild dementia[7]. However, the diagnosis of dementia can be difficult and the first sign of cognitive problems may be a crash.

The practice of "co-piloting," or having another individual guide a driver with dementia through the driving task, is not safe and should be strongly discouraged by health care professionals.

Diabetes[‡]:

1. Health care professionals should be aware that drivers with diabetes[15] as a group are at increased risk of having road crashes. Although it is agreed that the major risk involved is that associated with hypoglycemia[14], it appears that the hypoglycemic phenomenon by itself does not explain all the increased risk. Consequently, all drivers with diabetes should be counseled to the effect that they are at an increased risk and that even mild hypoglycemia should be avoided when they are driving. Patients should be counseled on the importance of frequent stops and snacks, easy availability of glucose supplements and early recognition of signs of impending hypoglycemia.

2. Health care professionals should be aware that DMVs[4] concentrate their efforts on those drivers who suffer hypoglycemic episodes that require the assistance of a third party. Professionals should counsel any driver who experiences such an episode to not drive until the driver's treating clinician is certain that the risk of a recurrence has been minimized. In some instances this period without driving may last several months and some experts feel that a 3-month period for almost everyone in this situation would be appropriate. However, it is the clinical judgment of the treating clinician that is the important factor since the individual's particular situation will be the major factor.

3. Recurrent hypoglycemic episodes that require third-party intervention are a counter-indication to driving. Resuming driving for such an individual will depend upon an informed opinion from the treating clinician.

4. Hypoglycemic unawareness, where the hypoglycemic episode occurs with no forewarning being perceived by the individual, is an absolute counter-indication to driving. As long as the unawareness persists, the person must be counseled to refrain from driving.

5. Insulin[29]-treated diabetes[15] is not, in itself, a justification for disqualification from driving. However, the potential for a hypoglycemic[14] episode is considered to be higher for the insulin-treated diabetic than for diabetics treated by oral medication. Consequently, health care professionals should provide patient education on the problems associated with driving and insulin-treated diabetes.

6. All drivers with diabetes should see their treating clinician at least annually. Those who encounter difficulties with control should be seen more frequently in accordance with their treating clinicians' assessment of the requirements for follow-up and control. Any changes in status — for example, the initiation of insulin treatment — should be communicated to the DMV, preferably by the drivers themselves.

7. Before recommending that their patient with diabetes continue driving, the treating clinician should ensure that there is a good understanding of the disease, that the patient is free of hypoglycemic episodes requiring third-party intervention and that

[‡] While the above recommendations came from the Driver Fitness Working Group, not all experts agree. Alternative viewpoints are presented in Appendix C.

the patient is willing to follow the suggested treatment plan. The patient's compliance with the suggested therapy and the maintenance of blood sugar readings within an acceptable range are important in establishing that the patient understands and is compliant in the management of the condition. The patient should demonstrate to the clinician that they are able to recognize incipient hypoglycemia[14] and can take the appropriate action when they become symptomatic.

Seizures:

1. Health care professionals should be aware that anti-epileptic drugs[30] (AEDs[31]) are known to produce side effects in some patients that may affect driving. Normally patients affected by AEDs will complain to their clinicians, who should then counsel them on restricting their driving until the side effects have passed. Such patients should have their levels of the drug monitored regularly and should be counseled to cease driving if toxic effects occur.

2. Following a unique seizure[17], the patient should be counseled to not drive while under investigation. Driving may be resumed if the neurological[32] and cardiac investigations have not revealed a cause or if a treatable cause has been identified and the therapy successful. If the neurological investigation reveals that the patient has epilepsy[16], the health care professional should counsel the patient that they will be subjected to the local jurisdiction's medical standard for epileptic seizures.

3. Following a diagnosis of epilepsy, the driver should undergo an annual examination by the treating clinician. The frequency of the controls by the treating clinician may be relaxed gradually in accordance with the treating clinician's clinical assessment of the situation.

4. Cessation of AEDs may lead to a new seizure. The driver who suffers a seizure following a prescribed cessation of AEDs should be counseled to not drive until therapeutic levels of AEDs are achieved that are comparable to the levels prior to the cessation of AEDs. A seizure following voluntary cessation of AEDs by the driver without medical supervision should be treated in the same manner as an unprovoked seizure.

5. Health care professionals should be aware that seizures[17] induced by the ingestion of alcohol or drugs must be followed by a 6-month period of abstinence before driving can be resumed. If substance abuse or dependence is present that meets the diagnostic criteria described in the Diagnostic and Statistical Manual of Mental Disorders[33] (DSM-IV[34]), driving is counter-indicated until the person meets the diagnostic criteria for prolonged remission. Jurisdictional requirements vary for alcohol treatment program attendance and other measures such as mandatory installation of ignition interlock devices.

Sleep Disorders:

1. Drivers who have obstructive sleep apnea[18] (OSA[19]) may be counseled by their health care professionals to continue to drive if there is no daytime drowsiness or if the AHI[21] is less than 20. Drivers with daytime sleepiness or an AHI of 20 or more may drive only if the condition has been treated effectively or as long as the patients continue the therapy. Ceasing the therapy should be accompanied by driving cessation if the OSA is still present.

2. Continuous positive airway pressure[35] (CPAP[36]) therapy has been shown to be an efficient treatment for OSA. Health care professionals should be aware that CPAP therapy reaches optimal effectiveness after 2 weeks but the effects disappear rapidly upon cessation of its use. Even a single night of non-compliance has been shown to adversely affect surrogate markers of crash risk.

3. In the event of therapeutic non-compliance for a patient with OSA[19], no matter what the reason, the health care professional should counsel that driving be ceased immediately.

4. Some sleep disorders are amenable to pharmaceutical treatment. When the treatment has eliminated the daytime drowsiness or the sudden onset of sleep, the patient may be counseled to resume driving for as long as the therapy is effective.

Recommendations for Drivers With At-Risk Conditions

General:

1. Most jurisdictions have regulations that require drivers to self-report any change in their medical condition. Generally, failure to do so may be grounds for suspension and, in some jurisdictions, criminal procedures.

2. In most cases, the ADA requires that States individually assess an applicant's fitness to drive safely, as through the review of medical documentation or the performance of written or on-road driving examinations. Under that statute and comparable State and local laws, the DMV must reasonably accommodate the needs of individuals with disabilities who can demonstrate their ability to drive safely.

Vision:

1. Generally, it is recommended that drivers whose visual acuity[5] just meets the standards should not drive at night. Darkness diminishes visual acuity so a person with a visual acuity that just meets the standard will have an effective visual acuity in darkness that is lower than the standard. Some jurisdictions will impose a restriction on the driver's license to this effect for such a driver.

2. Drivers who require correction of their visual acuity to meet the visual acuity standards for drivers must wear their corrective devices (e.g., glasses or contact lenses) when driving.

3. DMVs will base their decision for licensure upon the corrected visual acuity that is demonstrated by the driver in the visual test. It is in the driver's interest to have optimal correction. A DMV may advise a driver who fails the visual acuity test to seek specialist advice to improve visual acuity. Some States may offer restricted licenses on a case basis to drivers who even with correction cannot achieve the visual acuity standard.

Physical Limitations:

1. Drivers with progressive neuromuscular diseases[37] may be required to drive a vehicle that has been modified in order to permit manipulation of all the controls required for safe operation of the vehicle. Only an occupational therapist or a driving rehabilitation specialist is able to evaluate a driver with physical limitations in order to determine the appropriate modifications.

2. Most physical limitations can be accommodated by a vehicle modification. Only a small percentage of drivers must cease driving because of a purely physical limitation. However, when the physical limitation is accompanied by a cognitive limitation, learning to operate the modified controls can be difficult.

Dementia:

1. A driver who is identified as having a cognitive problem may be required to undergo certain tests that will evaluate problems associated with driving. The primary test is the on-road evaluation but there are tests that are administered in an off-road setting that are also used to evaluate certain cognitive functions necessary for safe driving. These evaluations may be conducted by the DMV[4] or by other professionals such as occupational therapists or driving rehabilitation specialists.

2. Many jurisdictions will not issue a restricted driver's license to someone with dementia[7] because the driver may not be able to comply with the restrictions.

3. The practice of "co-piloting," or having another individual guide a driver with dementia through the driving task is not safe and should be strongly discouraged.

Diabetes[§]:

1. Driving with diabetes[15] treated with oral drugs or insulin[29] can be a challenge. Drivers with diabetes must plan their trips taking into considerations the

[§] While the above recommendations came from the Driver Fitness Working Group, not all experts agree. Alternative viewpoints are presented in Appendix C.

particularities of their medical condition. Frequent stops, blood sugar checks every four hours, regular meals or snacks, and good hydration are essential for long trips.

2. Drivers should interrupt their trip if they feel symptoms of impending hypoglycemia[14] or if their blood sugar is lower than 70 mg/dL. They should not resume driving until they have recuperated completely.

3. Drivers with diabetes[15] treated with oral drugs or insulin[29] should wear a bracelet identifying them as having diabetes.

4. Any driver who suffers a hypoglycemic[14] episode necessitating the assistance of another person must cease driving immediately and not resume driving until their treating clinician has informed the driver that he or she may do so.

5. All drivers with diabetes should see their treating clinician on a regular basis. The frequency of visits will be determined by the clinician according to their assessment of the clinical situation.

Seizures:

1. Drivers with epilepsy[16] who require anti-epileptic drugs[30] must be monitored in order to avoid drug toxicity. Any driver who suffers from the side effects of AEDs[31] should immediately consult the treating clinician.

2. A new seizure[17] must be reported to the treating clinician immediately.

3. Drivers with epilepsy should see their treating clinicians on a regular basis. The frequency of visits will be determined by the clinician according to an assessment of the clinical situation.

Sleep Disorders:

1. Drivers with daytime drowsiness should not drive until the therapy suggested by the treating clinician has been shown to be effective. Even then, such drivers should monitor their drowsiness and cease driving immediately if they feel drowsy.

2. CPAP[36] has been demonstrated to be an effective treatment of OSA[19]. However, once initiated, the treatment must be continued for as long as the person wishes to maintain a driver's license. Any interruptions of CPAP, even if it's only for one day, can have adverse effects on driving safety. Since CPAP takes at least two weeks to be effective, any interruption in treatment means at least a two-week interruption in driving.

3. Drivers with untreated sleep disorders must not drive if they have daytime drowsiness or sudden onset of sleep.

4. Drivers with an AHI[21] score of 20 or more ("sleepiness index") must not drive unless treated effectively with CPAP or drugs.

Chapter 2: Physical Impairment

Introduction

This chapter examines various conditions that are associated with physical impairment of the driver. Generally speaking, an individual assessment of driver fitness is necessary to determine if modifications are appropriate and if driving is safe.

Amputation

An amputation[38] is the absence of a limb due to a congenital[39] limb deficiency or surgical removal of a limb following trauma or illness. The functional implication of the absence of a limb is the inability to operate one or more vehicle controls as intended by the vehicle manufacturer. Upper limb amputations limit access and control of the steering wheel, gear selector, directional signal, horn, lights, and other controls located on the dashboard. Right lower extremity amputations limit access and control of the vehicle accelerator and brake pedals. Left lower extremity amputations hinder access to the clutch in manual transmission vehicles and the emergency brake in some automatic transmission vehicles. When the loss of function is permanent, the impact upon driving will depend upon the extent of the loss of function. Minimal limitations may not require modification of the driver's vehicle. In fact, the majority of amputees are able to drive their own vehicle with no modification since most amputations involve the partial loss of one or several fingers or toes that have no affect on the physical functions required for driving.

The health care professional must assess the extent of the physical limitations and determine if further functional evaluation is indicated. If the health care professional or the DMV have any doubts about the capacity of the driver to perform the tasks required for driving safely, the driver must be subjected to further assessment, usually by an occupational therapist or a driving specialist. In-office evaluation by a physician is rarely adequate, especially when performed by professionals unversed in the practical aspects of driver evaluation. Since every case must be evaluated on its individual merits, there are no generalised rules of the type "If you have X, you cannot drive for 3 weeks." DMVs must assess each case individually, taking into consideration the individual characteristics of the person involved.

Review of Evidence on Driver Safety and Performance With Respect to Amputation:

Driver Safety: The literature review was unable to identify any studies that examined the relationship between drivers with amputations and safety, specifically motor vehicle collisions, injurious crashes, fatal crashes, or violations.

Driver Performance: A single study of sufficient rigor was conducted examining partial task performance of driving (brake reaction time) using a repeated measure design to determine the safest, most effective method of operating foot pedals following a right lower

extremity amputation. Meikle, Devlin, and Pauley (2006) studied four different techniques of foot pedal controls in lieu of the absence of the right lower extremity. In measures of reaction time, movement time, total response time, and preferred pedal configuration, it was determined that the slowest technique involved the prosthesis on the accelerator and left foot on the brake pedal. Use of a left foot accelerator was equivalent to using the right prosthesis on both pedals. Left-footed operation of both vehicle manufacturer's pedals was the fastest, although not likely realistic for extended real-life driving.

Table of the Quality of Evidence

Driving Pedal Reaction Time After Right Transtibial[40] Amputations (Meikle, Devlin, & Pauley, 2006)

Objective	Determine safety of right transtibial amputees and driving with a prosthetic foot: which of four techniques has fastest reaction times?
Level/Design Participants	Design: repeated measures (tested reaction, movement, and response time across four pedal configurations during single session in a random sequence; 10 subjects with right transtibial amputations at least 6 months after prosthetic fitting).
Intervention and Outcome Measurement	Outcome measure: Reaction time, movement time, total response time, and pedal configuration preference.
Results	Driving reaction times slowest in two-footed driving technique (P <.001). Total response time comparable using left-sided accelerator versus prosthesis (P =.07). Using left foot to operate both accelerator and brake in conventional right-footed accelerator designing led to fastest reaction and total response times (P<.001). Unclear if realistic driving technique for all amputees.
Limitations	Small sample size, brief duration of testing, lack of real driving situations, lack of testing of pedal pressure control, and artificial nature of testing apparatus, results cannot be used to make specific recommendations. This study does not provide adequate evidence to support or oppose use of left-sided accelerator.

Other Considerations:

Drivers with a right lower extremity amputation[38] must be examined for cognitive ability to determine which pedal configurations are realistic to understand and learn for safe and consistent operation. If the right lower extremity prosthesis will be used to operate the pedals, careful assessment of sensory awareness of foot location is critical to safe, consistent vehicle operation.

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:
Due to the small sample size and inconclusive results, no recommendations can be made about driving with a prosthetic lower extremity, using a left-foot accelerator, or use of the manufacturer's foot pedals. A two-footed technique with the prosthesis operating the accelerator and left foot operating the brake pedal is not recommended.

Chapter 2: Physical Impairment

Arthritis

Arthritis is an inflammation of the joints that is either age-related or caused by overuse, injury, or autoimmune mechanisms. The inflammation of the joint causes pain, decreased flexibility, instability of the joint, and may result in weakness of the effected limbs or torso. Any condition that affects the upper or lower limbs, the neck, and the back may have an effect on the patient's fitness to drive. The functional implications of arthritis as related to driving are limited ability to operate the vehicle primary controls including the foot pedals, steering wheel, ignition, gear selector, safety belt, and any other control requiring a reach, strength, or leverage. It is extremely rare that the driver's vehicle cannot be modified to accommodate a physical limitation. However, unless the appropriate evaluation of the driver's needs is performed, the driver may persist in driving a vehicle without modifications, thereby creating a situation that is potentially dangerous. Immobilizations of the upper limbs, especially immobilizations of the wrist, hand, or fingers, may have an adverse effect upon the driver's ability to manipulate the controls and the steering wheel. Health-care providers tend to ignore the effects of arthritis or other joint problems upon the person's ability to control the steering wheel whereas the simple adaptations could alleviate the person's prehensile problems.

Review of Evidence on Driver Safety and Performance With Respect to Arthritis:

Driver Safety: The literature review was unable to identify any studies that examined the relationship between drivers with arthritis and safety, specifically motor vehicle collisions, injurious crashes, fatal crashes, or violations.

Driver Performance: A single study of sufficient rigor was conducted to examine the driving performance of individuals with arthritis, specifically rheumatoid arthritis[41] (RA)[42], osteoarthritis[43] (OA)[44], low back pain with or without sciatica[45], fibromyalgia[46] (FM)[47], ankylosing spondylitis[48] (AS)[49], and miscellaneous arthritis. Jones, McCann, and Lassere (1991) examined 94 drivers with a driving evaluation that included an in-vivo[50] road test and found that while many had difficulty with specific aspects of the driving task, 82 percent were able to continue driving with or without minor safety adjustments.

Table of the Quality of Evidence	
Driving and Arthritis (Jones, McCann, & Lassere, 1991)	
Objective	Experience of driving assessment service based in the occupational therapy department of a rheumatology unit. Wanted to define difficulties faced by individuals with different types of arthritis and see how they could be overcome.
Level/Design Participants	94 patients assessed. Six categories: RA[42], OA[44]low back pain with or without sciatica[45], FM[47], AS[49], miscellaneous.
Intervention and Outcome Measurement	Comprehensive driving evaluation including an on-the-road test.
Results	Drivers with RA showed difficulties in all areas of function, mostly with hand and

	upper limb function and reaching the seat belt. Drivers with OA had problems reversing, steering, cornering, seating, and minimally lower limb functions. Those drivers with back pain/sciatica only had difficulties in seated use of foot pedals, and less frequently reversing, steering, and cornering. Some with FM had a wide range of difficulties, mostly spinal and lower limb function. Reversing was a problem with individuals with AS. Overall, 77 of 94 were considered safe to drive with or without minor safety adjustments. Fifteen were unsatisfactory, while two were deemed unsafe.
Limitations	Low representation in each category of patients.

Other Considerations:
Many limitations caused by arthritis can be reduced through adaptive equipment or adaptive strategies that can improve function, safety, and prevent further joint deterioration.

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:
Individuals with arthritis that disrupts functional performance in other areas of their lives should participate in a comprehensive driving evaluation by a trained driving rehabilitation specialist to determine areas of deficit, need for adaptive equipment or strategies, and to prevent further joint deformity.

Chapter 2: Physical Impairment

Cerebral Vascular Accident

A cerebral vascular accident[23] (CVA[51]), commonly referred to as a stroke, is caused by a lesion in the brain that can effect visual fields[6], hinder attention to one side of the body/environment, reduce problem-solving, interrupt communication skills for speech, understand spoken language, and impair physical strength, range of motion, coordination, and sensation on one side of the body. The physical functional implications of a stroke as related to driving are limited ability to operate the vehicle controls on the effected side of the body. Drivers with a left CVA may have decreased motor control, sensation, and strength on the right side of the body, limiting their ability to operate the gear selector, ignition, windshield wipers, steer while operating the directional signal, fasten and unfasten the seat belt, and operate the accelerator and brake pedals. Drivers with a right CVA may have decreased motor control, sensation, and strength on the right side of the body, limiting their ability to operate the directional signal, reach for the seat belt, perform tasks with both hands simultaneously, and operate the clutch on a manual transmission vehicle.

Review of Evidence on Driver Safety and Performance With Respect to Cerebral Vascular Accident:

Driver Safety: The literature review was unable to identify any study that examined the relationship between drivers sustaining a CVA and safety, specifically motor vehicle collisions, injurious crashes, fatal crashes, or violations.

Driver Performance: A single study of sufficient rigor examined the physical ability to return to driving following a CVA. Lings and Jensen (1991) examined driving performance on a simulator and found that individuals with both left and right hemiparesis[52] exhibited decreased reaction time while those with right hemiparesis made significantly more errors in driving than their healthy controls.

Table of the Quality of Evidence	
Driving After Stroke: A Controlled Laboratory Investigation (Lings & Jensen, 1991)	
Objective	Determine the capacity of individuals with left- and right-sided CVAs to operate a motor vehicle.
Level/Design Participants	Descriptive study of 109 people who had sustained CVAs (46 with left hemiparesis; and 67 with right hemiparesis).
Intervention and Outcome Measurement	Partial task simulator measuring driving performance against control groups.
Results	*Left-sided hemiparesis* related to reaction time, but spasticity was not associated. No statistically significant differences in the number of errors between the study and control groups. *Right-sided hemiparesis*: the degree of paresis[53] correlated significantly with reaction times, while no relationship existed between spasticity and reaction time. Significant increase in directional errors compared to the control group (x^2=7.8, df=1, p<.01). Results illustrate magnitude and severity of difficulties for post

	stroke patients in operating car controls.
Limitations	Results of simulator-based testing cannot be predicted on basis of a clinical examination alone. An assessment of driving capability can not be made on the basis of clinical examination alone.

Other Considerations:

An individual who has sustained a CVA[51] can present with deficits in several areas, namely visual, cognitive, motor, and sensory. Practitioners and licensing agencies should use caution in making licensing decisions based on outwardly visible limitations. Many individuals can return to safe driving following a comprehensive evaluation and training in the use of adaptive equipment.

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 the complicated and variable nature of cerebral vascular accidents with regard to size, location, and severity, individuals should be considered on a case-by-case basis with comprehensive driving rehabilitation evaluation by a trained driving rehabilitation specialist to determine fitness to drive.

Chapter 2: Physical Impairment

Multiple Sclerosis

Multiple sclerosis[54] (MS[55]) is a progressive neurological[32] disorder of unknown origin that affects vision (double vision), cognition (problem-solving, attention, and memory), sensation, and physical strength. Individuals with multiple sclerosis may have difficulty visually interpreting the driving environment, traveling through complex driving environments, remembering where they are going, transferring in and out of the vehicle, turning the key in the ignition, feeling the pedals under their feet, rotating the steering wheel with enough force to turn the vehicle, depressing the foot pedals to stop when necessary, or operating the vehicle while seated in a power wheelchair.

Review of Evidence on Driver Safety and Performance With Respect to Multiple Sclerosis:

Driver Safety: A cohort study examined the relationship between a clinically based multiple sclerosis functional composite (MSFC[56]) and driving and found a significant correlation to crashes reported to the DMV[4] (r = -.40, p<.05) (Shawaryn, Schultheis, Garay, & DeLuca, 2002). Lings (2002) conducted a cohort study examining 10 years of data and found a significant increase of emergency department treatments as a result of automobile crashes among individuals with MS compared to their health counterparts (ratio 3.46).

Driver Performance: No sufficiently rigorous evidence exists examining drivers with MS and partial or full task driving performance.

Table of the Quality of Evidence	
Assessing Functional Status: Exploring the Relationship Between the Multiple Sclerosis Functional Composite and Driving (Shawaryn, Schultheis, Garay, & DeLuca, 2002)	
Objective	Explore the relationship between the MSFC and driving.
Level/Design Participants	Cohort study with 29 individuals with MS[55].
Intervention and Outcome Measurement	MSFC that measures arm, hand, and, leg function, ambulation, and cognition; Neurocognitive Driving Test (NDT[57]); violations and crashes per DMV records.
Results	Overall score on the MSFC was moderately correlated with the DMV crashes (r = -.40, p<.05) and not associated with DMV violations (-.18). Subtests of the MSFC were not correlated with DMV violations, DMV crashes, or self-report crashes.
Limitations	Only individuals with minimal or no physical involvement were included. The period of time for which DMV records were gathered was not reported.

Table of the Quality of Evidence	
Driving Accident Frequency Increased in Patients With Multiple Sclerosis[54] (Lings, 2002)	
Objective	Assess the influence of MS[55] on the ability to drive safely.
Level/Design Participants	10 year cohort study, 197 participants with MS and 545 controls.

Intervention and Outcome Measurement	Treatment at the emergency department following a crash in which the person with MS was the driver.
Results	Drivers with MS were more likely to be seen in the emergency department from a crash than their healthy counterparts at a ratio of 3.46 (p = .04). Crashes with the study group were all collisions with other vehicles while the healthy controls collided mostly with fixed objects or without a counterpart.
Limitations	Only those treated in the emergency room were included, which omits smaller crashes that did not involve injury.

Other Considerations:

Individuals with multiple sclerosis can often drive for extended periods of time following diagnosis with proper evaluations and training in the use of adaptive equipment to compensate for physical deficits. Careful consideration should be paid to the driver's cognitive status and their ability to learn and safely use new equipment. While different classifications of multiple sclerosis exist, published studies do not explicitly identify which types of the disease are included in the studies. Therefore the evidence does not suggest any differences in driving ability or safety based on type of multiple sclerosis. There is also no evidence to suggest a benefit or risk associated with timing of medication for individuals with multiple sclerosis as this variable was not included in the published studies.

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 the complicated and variable nature of multiple sclerosis, potential for visual, cognitive, motor, and sensory impairment, drivers should be considered on a case-by-case basis with comprehensive testing by a trained driving rehabilitation specialist to determine fitness to drive. Also, given the progressive nature of the illness, individuals should be evaluated upon diagnosis to establish baseline scores and periodically thereafter to prolong driving privileges as long as possible.

Chapter 2: Physical Impairment

Parkinson's Disease

Parkinson's disease[58] is a progressive neurological[32] disorder that manifests itself with physical symptoms (akinesia[59], tremors[60], dyskinesia[61], bradykinesia[62], postural problems, and joint rigidity), psychiatric symptoms (dementia[7], confusion, and hallucinations[63]), and cognitive symptoms (concentration, visual perception, processing speed, and reaction time). Drivers can have any number of these symptoms to varying degrees depending on the stage of progression and symptom management with medications. The functional implications for driving include difficulty transferring in/out of the vehicle, reaching for and fastening/unfastening the seat belt, inserting the key in the ignition and turning, steadily rotating the steering wheel, accurately reaching for vehicle controls on the steering column and dashboard area, turning head to scan environment visually, and smoothly depressing/releasing the foot pedals. The psychiatric and cognitive symptoms of PD[64] also have driving implications related to difficulties in timely decision making, judgment, problem solving, attending to the driving task and driving environment simultaneously, memory, and navigating through complex driving environments.

Review of Evidence on Driver Safety and Performance With Respect to Parkinson's Disease:

Driver Safety: The literature review was unable to identify any study that examines the relationship between drivers with Parkinson's disease and safety, specifically motor vehicle collisions, injurious crashes, fatal crashes, or violations.

Driver Performance: Much of the research on drivers with Parkinson's disease has focused on measuring driving performance reaction time because of the vast number of performance deficits drivers can exhibit. Borromei and colleagues (1999) examined one portion of driving, reaction time, during a simulated driving task and found that reaction time increased with age, was slower for drivers than the reaction time norms, and was faster in response to aural stimulus compared to visual stimulus. Another study measuring partial task performance measured steering and stopping at a red light against a control group of healthy drivers and revealed that drivers with PD have less accuracy, slower reaction time, and miss more red lights while those who had progressed further in the disease process performed worse (Madeley, Hulley, Wildgust, & Mindham, 1990). Stolwyk and colleagues also studied partial driving task performance by comparing simulator driving between drivers with PD and healthy controls. The researchers found several performance discrepancies between the groups including slower approaches to signals, later initiation of deceleration, travel past traffic signals, slower travel through curves, and higher variability in lateral lane position (Stolwyk, Triggs, Charlton, Iansek, & Bradshaw, 2005). While they did find performance differences, they did not find relationships between performance and motor function, including scores on the Unified Parkinson's Disease Rating Scale[65] (UPDRS[66]), severity of illness, or reaction time.

Driver Performance continued:
Other studies aimed to find clinical measures that were predictive of driving performance on roadways. Most studies found a substantial portion of the drivers (over half) to be safe with varying results in the ability of other measures to predict driving performance. Grace and fellow researchers (2005) found 67 percent of the participants with PD[64] to be safe with predictive tools being the motor scale of the UPDRS[66] (specifically postural stability, speech, facial expression, and neck rigidity items), and Hoehn & Yahr ratings. Radford, Lincoln, and Lennox (2004) found 64 percent of the participants with Parkinson's[58] to be safe with relationships between driving and the Webster's Rating Scale[67] and select items from the Stroke Drivers Screening Assessment[68] (SDSA[69]), specifically Dot Cancellation task, Adult Memory and Information Processing Battery[70] (AMIPB[71]) Story Recall, and AMIPB Information Processing A. Uc and colleagues (2007) used similar clinical assessments in their battery while searching for links to driving performance and found that drivers with PD made more errors and tended to drive slower while discovering that cognition and vision tests were better safety predictors than motor assessments. In another effort to identify clinical assessment tools predictive of driving performance, Worringham and colleagues (2006) found the Purdue Pegboard test[79] to be a predictor of pass-fail on the road test and associated with safety while the UPDRS was not predictive. In a study comparing driving performance between individuals with PD and healthy controls, Wood and fellow researchers found that those with PD are significantly less safe than their healthy counterparts and scored at a level would have resulted in a failure in the licensing agency's driving test.

Table of the Quality of Evidence

Ability and Fitness to Drive of Parkinson's Disease Patients (Borromei, Caramelli, Chieregatti, d'Orsi, Guerra, Lozito, et al., 1999)	
Objective	Identify the correlation between PD symptoms and number of accidents when compared to the general population.
Level/Design Participants	N=204 participants diagnosed with PD, average age of female participants was 72.4 years and males was 70.6.
Intervention and Outcome Measurement	Partial task measure of reaction time was compared to Webster scale and Crichton Geriatric Behavioral Scale. Participants were also asked for the reason why they did or did not drive.
Results	Reaction time increased with age. Reaction time was slightly faster to aural stimuli (250 msec[72]) compared to visual stimuli (338 msec). Both times were slow compared to healthy norms with a 13.5 percent time increase for visual and 10 percent time increase for aural stimuli.
Limitations	Reaction time alone is not indicative of driving performance.

Table of the Quality of Evidence	
Neuropsychological Deficits Associated with Driving Performance in Parkinson's[58] and Alzheimer's Disease[12] (Grace, Amick, Abreu, Festa, Heindel, & Ott, 2005)	
Objective	Compare how motor and cognitive function relates to on-road driving performance in individuals with PD[64] and Alzheimer's disease.
Level/Design Participants	Cohort study $N = 21$ with mild to moderate PD, 21 mild AD[13], 21 healthy older adult controls.
Intervention and Outcome Measurement	Neuropsych battery of tests: - Motor scale of the Unified Parkinson Disease Rating Scale[65] (UPDRS[66]) - Hoehn and Yahr Staging Scale[73] - Trailmaking Test[26] - Finger Tapping Test[74] - Standardized road test
Results	Sixty-seven percent of PD participants were found to be safe drivers but had a mean of 7.6 errors on the road test. The finger-tapping test was not predictive of driving safety. Some items on UPDRS motor scale were significantly correlated with driving ability (postural stability, speech, facial expression and neck rigidity). Hoehn and Yahr results of severity of PD were correlated with driving performance (marginal performance).
Limitations	Small sample size and only included people with mild to moderate PD.

Parkinson's Disease and Driving Ability (Madeley, Hulley, Wildgust, & Mindham, 1990)	
Objective	Explore how PD affects driving safety.
Level/Design Participants	Case control study of 10 drivers with PD, 4 nondrivers diagnosed with PD, and 10 healthy drivers.
Intervention and Outcome Measurement	Partial task (steering and stopping at a red light) measure of reaction time on a driving simulator Webster's rating scale[67] was used to determine the motor impairments of the PD participants.
Results	Drivers with PD showed impairments in accuracy (U=21.0, p=.01), reaction time (U=17.0, p=.006), and missed red lights (U=34.5, p=.12) when compared against healthy controls. The severity of PD was found to be correlated with driving safety issues for reaction time (r=.53), accuracy (r-, 78), simple reaction (r=.63).
Limitations	Can not generalize results due to small sample size and selection bias.

The Effects of Cognitive Abilities Driving in People with Parkinson's Disease[58] (Radford, Lincoln, & Lennox, 2004)	
Objective	Create a screening process to determine possible cognitive problems related to driving safety.
Level/Design Participants	Two group comparison, $N = 51$ participants diagnosed with PD, age 44 to 85 who currently drive.
Intervention and Outcome Measurement	Webster's Rating Scale, UPDRS, SDSA[69], and a tapping task. Outcome measure: determination of safety with an on road assessment.
Results	- 33 found to be safe drivers. - Unsafe drivers identified by Webster's Rating Scale. - Correlations were found between the SDSA Dot Cancellation task, AMIPB Story Recall and AMIPB Information Processing A and driving safety ($p < .05$).
Limitations	All participants were currently driving, therefore the sample may not have accurately represented people with PD.

Impact of Internal Versus External Cueing on Driving Performance in People with Parkinson's Disease[58] (Stolwyk, Triggs, Charlton, Iansek, & Bradshaw, 2005)	
Objective	Explore the correlation between neuropsychological[75] test outcomes and driving simulator performance.
Level/Design Participants	Nonrandomized control trial, *N* = 18 participants diagnosed with Parkinson's Disease[58] and 18 control participants, age 54 to 78.
Intervention and Outcome Measurement	Partial task (negotiating traffic signals and curves) on a driving simulator.
Results	Compared with controls, participants with PD[64] approached signals slower (F [1,34] =3,42; *p*=.073), initiated deceleration later (*F*[1,34] = 21.58;*P* <.001), traveled further past traffic signals (*F* [1,34] =26.76; *P*<.001), traveled through curves at slower speeds (*F* [1,34] =7.13; *P*=.012), and had higher variability in lateral lane position (*F*[1,34] =11.08; *P*=.002). Motor function, reaction time, and severity of illness were found to not be significantly correlated with the specified driving behaviors. This included the motor section of the UPDRS[66], which is widely used to determine the severity of PD[64].
Limitations	Small sample size. Only looked at the correlation of the tests to the STI driving simulator and did not look at the predictability of the tests on STI simulator performance. The study also had a small sample size with an inaccurate representation of women.

Impaired Navigation in Drivers with Parkinson's Disease (Uc, Rizzo, Anderson, Sparks, Rodnitzky, & Dawson, 2007)	
Objective	Investigate driving safety when completing a route-following task[76] (RFT[77]).
Level/Design Participants	Nonrandomized control trial, *N* = 77 drivers diagnosed with mild-moderate and 152 healthy driver controls.
Intervention and Outcome Measurement	- UPDRS - Tapping test[74] - Walking speed test - Standardized road test - On-road route-following task
Results	PD participants made more errors than the healthy controls. PD drivers tended to drive slower, however there was no significant difference between variability of speed and steering. Found that cognition and vision were better predictors of safety than motor impairments.
Limitations	All participants still drove, which could exclude people with more severe symptoms.

Quantitative Assessment of Driving Performance in Parkinson's Disease[58] (Wood, Worringham, Kerr, Mallon, & Silburn, 2005)	
Objective	Determine how PD[64] affects driving performance.
Level/Design Participants	Nonrandomized matched control trial, *N* = 25 PD participants mostly with moderate systems and 21 controls.
Intervention and Outcome Measurement	Standardized on-road test.
Results	Drivers with PD significantly less safe when compared against controls (*t*=3.26; *p*=.002). Fourteen of the 25 drivers with PD scored at a level that would have resulted in failing the licensing agency's driving test.

Limitations	Small sample size.
Predictors of Driving Assessment Outcome in Parkinson's Disease (Worringham, Wood, Kerr, & Silburn, 2006)	
Objective	Evaluated the ability of functional tests to predict driving performance in PD.
Level/Design Participants	Nonrandomized matched control trial, $N = 25$ PD participants mostly with moderate systems and 21 controls.
Intervention and Outcome Measurement	-UPDRS[66] -Aiming task[78] -Coincidence- Anticipation -Purdue Pegboard test[79] -On-road test
Results	Purdue Pegboard test was found to be a good predictor of driving ability against pass-fail (t=3.59; p<.005) and correlated to safety score (r=.54). UPDRS was not predictive of driving and only minimally correlated to safety (r= -.24).
Limitations	Small sample size.

Other Considerations:

Individuals with Parkinson's disease likely use prescription medication to alleviate or manage their symptoms and therefore all medication contraindications[80] should be considered, particularly drowsiness as a common side effect. There is no evidence to suggest a benefit or risk associated with timing of medication because all studies reviewed included a strict inclusion criterion of peak medication levels to control for functional level and reduce confounding variables.

Recommendation:

☐ 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:

Most of the existing literature identifies discrepancies in driving performance for individuals with Parkinson's disease[58]; however a conclusive link to safety, crashes, injuries, or fatalities has not been made. Due to the highly individualized nature of the disease and variable progression, individuals in question should participate in a comprehensive driving evaluation by a trained driving rehabilitation specialist.

There was significant variability and even contradictions in the studies specific to which tests were predictive of driving performance and safety, therefore agencies and providers should use caution when assigning pass-fail thresholds to assessments for determination of safety or licensure. Licensing agencies and healthcare providers should also use a driving test to measure performance in determining medical fitness to drive.

Given the progressive nature of the illness, individuals should be evaluated upon diagnosis to establish baseline scores and periodically thereafter to prolong driving privileges as long as possible.

Chapter 2: Physical Impairment

Spinal Cord Injury

A spinal cord injury is a lesion, injury, or severing of the spinal cord that limits or prevents motor and sensory function from the location of the injury down. The severity of functional involvement is highly dependent upon the location of the injury (cervical[81], thoracic[82], or lumbar[83] region of the spine) and the completeness of the injury (a complete sever versus an incomplete injury in which only some of the spinal cord fibers are affected). The most severe injuries result in total paralysis and sensory loss from the location of the injury down to the feet. The functional implications for driving may include (depending on the level and severity of the injury) difficulty transferring in/out of the vehicle, fastening/unfastening the seat belt, maintaining an upright sitting position while the vehicle is moving, turning the key in the ignition, operating the vehicle while seated in a power wheelchair, operating the foot pedals, rotating the steering wheel, selecting gears, activating the directional signal, sounding the horn, operating the lights, and any other vehicle controls attached to the steering column or located in the dashboard area.

Review of Evidence on Driver Safety and Performance With Respect to Spinal Cord Injury:

Driver Safety: The literature review was unable to identify any study that examines the relationship between drivers with spinal cord injuries and safety, specifically motor vehicle collisions, injurious crashes, fatal crashes, or violations.

Driver Performance: No sufficiently rigorous evidence exists examining drivers with spinal cord injuries and partial or full task driving performance.

Other Considerations:
Spinal cord injuries are highly variable based on vertebral level, completeness of the injury, and level of immediate medical intervention and therefore should be considered on a case-by-case basis following a comprehensive driving rehabilitation evaluation to determine the need and a capacity for adaptive equipment to compensate for motor loss. Many individuals can return to safe, independent driving following a spinal cord injury with the assistance of a driving rehabilitation evaluation and training in the use of proper adaptive equipment to meet the driver's needs.

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.

Chapter 2: Physical Impairment

Traumatic Brain Injury

Traumatic brain injuries[24] can be caused by any number of insults to the head including a fall, automobile crash, gunshot wound, and possibly even a non-traumatic cause such as a tumor. Functional limitations in people who have sustained brain injuries are highly variable depending on the location and size of the lesion in the brain. There is a array of possible deficit areas that may include one or more of the following: visual changes (double vision, visual field loss, perceptual deficits), cognitive changes (difficulties in problem solving, attention, judgment, memory), and physical changes (abnormal muscle tone in any or all of the limbs, impaired balance, decreased strength, contracted joints, decreased sensation). The functional implication of brain injuries for driving is the inability to operate one or more vehicle controls as intended by the vehicle manufacturer. Drivers may have decreased motor control, sensation, and strength, limiting their ability to transfer in and out of the vehicle, reaching for and fastening/unfastening the seat belt, turn the key in the ignition, operate the gear selector, windshield wipers, directional signal, steering wheel, feel and depress the accelerator and brake pedals, and operate the vehicle while seated in a power wheelchair. Performance of tasks with both hands simultaneously may prove to be particularly difficult. Drivers with visual and/or cognitive changes may have difficulty visually interpreting the driving environment, traveling through complex driving environments, and remembering where they are going.

Review of Evidence on Driver Safety and Performance With Respect to Traumatic Brain Injury:

Driver Safety: In a systematic review of the literature, McCabe and colleagues (2007) found that while 50 percent of people with severe TBI[84] and 75 percent moderate TBI return to driving, those who resume driving against professional recommendations have a higher crash risk. Haselkorn, Meuller, and Rivara (1998) examined the risk of drivers following brain injuries and found that there was no increased risk of crashes, but the prevalence of violations increased among those with brain injuries. In an attempt to predict driving performance following a brain injury, researchers examined individuals for one year following their rehabilitation and found that measures of motor performance were not predictive, but pre-injury driving, personality, and violations were predictive of crashes and violations.

Driver Performance: A study using both simulator and on-road measures of driving performance found individuals with brain injuries significantly worse at driving compared to the healthy controls in speed control, direction control, handling of vehicle controls, regulation of trajectory, basic maneuvers, and high-order skills. The road test was not related to driving performance at a 10-month follow up. Additionally, measurement of skills on the simulator was more sensitive and accurate than measurement through professional or family observation (Lew, Poole, Lee, Jaffe, Huang, & Brodd, 2005).

Table of the Quality of Evidence	
Characteristics of Drivers and Driving Record After Traumatic and Nontraumatic Brain Injury (Haselkorn, Mueller, & Rivara, 1998)	
Objective	Determine whether individuals with a TBI[84] or stroke[23] have an increased risk of subsequent motor vehicle crash or moving violations.
Level/Design Participants	Retrospective cohort study. Four cohorts of participants; 1,910 with CVA[51], 896 with TBI, 4,369 with fractures, and 2,409 with appendicitis.
Intervention and Outcome Measurement	State records of crashes and citations for 12 months following.
Results	Drivers with TBI do not have an elevated risk of crashes following hospitalization compared to the matched non-hospitalized cohort. With adjustments for prior driving record, those with TBI had an elevated risk of driving violations (RR = 1.3, 1.0-1.7).
Limitations	Unable to distinguish severity of brain injury due to retrospective nature of study.

Predictive Validity of Driving Simulator Assessments Following Traumatic Brain Injury[24]: A Preliminary Study (Lew, Poole, Lee, Jaffe, Huang, & Brodd, 2005)	
Objective	Evaluate whether driving simulator and road tests can predict long-term driving performance.
Level/Design Participants	Prospective study on 11 patients with moderate to severe TBI. Sixteen healthy subjects tested to provide normative values on simulator at baseline. Time ranged from 2 to 25 months post-TBI. Two phases: 1 month then 10 months later came in again.
Intervention and Outcome Measurement	Initial evaluation measures: - Simulator Performance Index (SPI[85]) - Driver Performance Inventory (DPI[86]) - Road test 10-month follow up: - Family observation using Driver Performance Inventory
Results	TBI group scored more than 4 standard deviations below normal control on SPI (t = 3.83, p=.001) and DPI (t = 5.36, p<.001). TBI group significantly impaired on both simulator subscales: speed control and direction control. Observational ratings of TBI simulator performance were significantly poorer on: - handling of controls; - regulation of trajectory; - basic maneuvers; and - high-order skills. Road test results at evaluation showed no significant relation to driving performance follow-up. Simulator skills more sensitive and accurate than observational skills of measures of simulator.
Limitations	Small sample size. Untrained person evaluation follow-up performance.

Community Reintegration Following Acquired Brain Injury (McCabe, Lippert, Weiser, Hilditch, Hartridge, & Villamere, 2007)	
Objective	Evaluate intervention and strategies to enable transition from acute care or post-acute rehab to community following brain injury.
Level/Design Participants	Systematic literature review.
Intervention	Evidence of return to driving in existing literature from 1980-2005.

and Outcome Measurement	
Results	Perino and Rago (1997) estimated only 50 percent of people with severe TBI[84] and 75 percent moderate TBI return to driving. Those who resume driving against professional advice have a high crash risk (Formisano et al., 2005).
Limitations	Lack of randomized control trials.

Role of Premorbid[87] Factors in Predicting Safe Return to Driving After Severe TBI (Pietrapiana, Tamietto, Torrini, Mezzanato, Rago, & Perino, 2005)	
Objective	Explore predictability of safe driving following severe traumatic brain injury[24].
Level/Design Participants	Sixty-six pairs of adults; each pair consisted of one with a brain injury and one healthy relative or significant other.
Intervention and Outcome Measurement	Measures: - Functional Independence Measure[88] (FIM[89])-Functional Assessment Measure[90] (FAM[91]) - Driving records by personal and family report
Results	About 50 percent of survivors of TBI resume driving; nearly two-thirds did so without specific medico-legal examination or formal evaluation. FIM-FAM scores were not predictive for post-injury driving. Factors most predictive were: - # years post-injury - Pre-TBI accidents and violations - Pre-TBI risky personality index - Pre-TBI risky driving style index
Limitations	FIM-FAM measures are unrelated to driving safety.

Other Considerations:

Drivers with traumatic brain injuries typically have a variety of deficit areas in addition to risk of seizures and may be using prescription medication to reduce symptoms. All medication contraindications[80] should be considered, including drowsiness and medication interactions. For guidance on seizures, please see page 82.

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 the complicated and variable nature of traumatic brain injuries[24] based on size, location, and severity, individuals should be considered on a case-by-case basis. While more than half of the individuals with moderate and severe brain injuries return to driving, resumption of driving should not be done without a comprehensive driving evaluation by a trained driving rehabilitation specialist to properly assess vision, cognition, motor, and safe driving performance.

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

Contrast Sensitivity Impairment

Contrast[105] refers to the light-dark transition at the border or edge of an image or object that defines the existence of a pattern or an object. Contrast sensitivity[25] refers to the amount of contrast a person needs in order to detect or identify an object or pattern. A person who has poor contrast sensitivity requires a higher contrast to see objects or patterns than a person who has good contrast sensitivity. There are a number of different methods for measuring contrast sensitivity. One of the most popular involves reading letters from a chart. As one moves down the chart, the size of the letters stay the same, but the contrast of the letters is reduced such that it is increasingly difficult to read the letters correctly. Impairment in contrast sensitivity can result from a number of different eye and neurological[32] conditions. Cataract[93] is a common cause of contrast sensitivity impairment in older adults. Other causes of contrast sensitivity impairment[106] include but are not limited to macular degeneration[92], 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 Contrast Sensitivity Impairment:

Driver Safety:

There are very few studies that have examined to what extent contrast sensitivity impairment is associated with an increased crash rate. One study focused on older drivers with cataract and found that older drivers with seriously impaired contrast sensitivity (Pelli-Robson test scores of ≤ 1.25) were much more likely to have a recent history of at-fault crash involvement compared to those with good contrast sensitivity [1]. Another study focused on license renewal applicants and found that the inclusion of a contrast sensitivity test in the vision screening process significantly strengthened the ability to identify older drivers with a recent history of crash involvement [2]. A recent study on a population-based community sample of older adults found no association between contrast sensitivity and incident crash involvement [3].

Driver Performance:

A study simulated cataracts in older drivers, which caused contrast sensitivity impairment whereas acuity was still within the vision standard for licensure [4]. On-road driving performance was then evaluated on a closed-road course with results indicating that those with impaired contrast sensitivity were more likely to have reduced ability to maneuver the vehicle. A recent study evaluated driving performance before and after second-eye cataract surgery and found that improvement in contrast sensitivity was predictive of improvement in driving performance following cataract surgery [5].

Reference Number	Compete Citation (With Quality of Evidence)
1	Owsley, C. et al. (2001). Visual Risk Factors for Crash Involvement in Older Drivers With Cataract. Archives of Ophthalmology, 119:881-887. [moderate]
2	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]
3	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]
4	Wood, J. M., & Troutbeck, R. (1995). Elderly Drivers and Simulated Visual Impairment. Optometry & Vision Science, 72:115-124. [moderate]
5	Wood, J. M., & Carberry, T. P. (2006). Bilateral Cataract Surgery and Driving Performance. British Journal of Ophthalmology, 90:1277-1280. [moderate]

Other Considerations:

The California Department of Motor Vehicles has been using contrast sensitivity[25] testing on a limited and experimental basis in some license renewal offices. Preliminary results imply this test may add some predictive ability to identify drivers at risk for crash involvement beyond that provided by visual acuity[5], particularly in those 70 and older. The California studies also revealed that a contrast sensitivity screening test was publicly acceptable, brief, and easy for examiners to administer. Results from the final evaluation will not be available for several years.

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:

Since there are not a large number of studies evaluating associations between contrast sensitivity and crash involvement, particularly population-based studies in a license renewal setting, one must be very cautious about making recommendations that it be added as a vision screening test for licensure. The preponderance[107] of data thus far, however, does suggest that contrast sensitivity testing may be highly promising as a screening tool for licensure in that it may add something over and above current vision screening approaches for identifying older drivers at high risk for unsafe driving. However further evaluation of this issue using population-based samples are needed before a recommendation can be made as to contrast sensitivity's utility as a screening test for licensure.

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

Color Vision Deficits

Color vision deficit[111] is a general term that refers to impairment in the ability to discriminate among colors, and can either be inherited, or acquired later in life. There are many different types of color vision deficits. There are many screening tests for detecting color discrimination problems. The public often refers to color vision deficits as "color blindness." Inherited forms of color vision deficits are much more common among men than women, with an estimated 8 percent of the male population affected by these conditions. Acquired color vision deficits can be caused by many conditions including but not limited to macular degeneration[92], cataract[93], optic neuritis[94], glaucoma[95], retinal degenerations (e.g., retinitis pigmentosa[96], Stargardt disease[97]), diabetic retinopathy[98], optic atrophy[99], brain injury (e.g., stroke, trauma, tumor), and diseases of the cornea[100].

Review of Evidence on Driver Safety and Performance With Respect to Color Vision Deficits:

Driver Safety:
A review of the literature on color vision and driving indicates that color deficiency does not elevate the risk of crash involvement [1].

Driver Performance:
Color deficiency may theoretically pose difficulty in interpreting traffic control devices in some situations; however the critical cues from these signals can be generally obtained from multiple sources of information, allowing drivers with color vision deficits to compensate.

Reference Number	Compete Citation (With Quality of Evidence)
1	Vingrys, A. J., & Cole, B. L. (1988). Are Color Vision Standards Justified for the Transport Industry? Ophthalmic & Physiological Optics, 8:257-274. [overview]

Other Considerations:
Some color deficiencies that are acquired (in other words, they are due to eye or neurological[32] conditions that are not inherited or present from birth) can co-occur with other types of vision impairments (for example, visual acuity[5] impairment). In these situations, while the color vision problem itself may not be a source of driver safety and performance problems, the other visual problems could lead to unsafe driving. Thus, it is important to consider several aspects of vision during the licensure process (see other parts of this report).

Currently there are Federal policies that require color vision screening for drivers of commercial vehicles, buses and similar vehicles that come under the jurisdiction of the Federal Motor Carriers Safety Administration[112] (FMCSA[113]). The present document speaks to the issue of drivers of personal vehicles and does not address vision-screening standards under FMCSA jurisdiction.

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 must be able to discriminate between the different traffic lights, but color vision deficiency by itself should not be a barrier to obtaining a driver's license for a personal vehicle.

Chapter 3: Vision

Slowed Visual Processing Speed

This functional deficit refers to a slowing in the speed at which a person processes visual information, particularly as related to recognizing and identifying objects and patterns and making decisions about them. Many tests have been developed to assess visual processing speed; among the most common are the Trails A and B tests[26]. Slowed visual processing speed is common among older adults, people with brain injury (e.g., stroke[23], trauma, tumor), and older adults with Alzheimer's disease[12].

Review of Evidence on Driver Safety and Performance With Respect to Slowed Visual Processing Speed[114]:

Driver Safety:

Several studies have shown that slowed visual processing speed in older drivers is associated with crash involvement [1-3].

Driver Performance:

Several studies have shown that slowed visual processing speed is associated with deficits in on-road and simulator driving performance [4-7].

Reference Number	Compete Citation (With Quality of Evidence)
1	Owsley, C., et al., (1998). Visual Processing Impairment and Risk of Motor Vehicle Crash Among Old Adults. JAMA, 279:1083-1088. [moderate]
2	Ball, K., et al., (2006). Can High Risk Older Drivers Be Identified Through Performance-Based Measures in a Department of Motor Vehicles Setting? Journal of the American Geriatrics Society, 54:77-84. [moderate]
3	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]
4	Roemer, D. L., et al., (2003). Speed-of-Processing and Driver Simulator Training Result in Improved Driving Performance. Human Factors, 45:218-233. [moderate]
5	Wood, J. M., &Troutbeck, R. (1995). Elderly Drivers and Simulated Visual Impairment. Optometry & Vision Science, 72:115-124. [moderate]
6	Cushman, L. A.(1996). Cognitive Capacity and Concurrent Driving Performance in Older Drivers. IATSS Research, 20:38-45. [moderate]
7	Duchek, J. M., et al., (1998). Attention and Driving Performance in Alzheimer's Disease. Journal of Gerontology: Psychological Science, 53B:P130-P141. [moderate]
8	Rizzo, M., et al., (1997). Simulated Car Crashes and Crash Predictors in Drivers with Alzheimer's Disease. Archives of Neurology, 54:545-551. [moderate]

Other Considerations:

Tests of visual acuity[5], visual fields[6], and contrast sensitivity[25] do not screen for visual processing speed, and thus will not identify drivers with slowed visual processing speed[114].

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:
Since slowed processing speed has been repeatedly shown to be associated with driver safety and performance problems, jurisdictions should consider implementing a screening test for licensure and/or re-licensure that assesses processing speed.

Chapter 3: Vision

Hemianopia

Homonymous hemianopia[115] 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.

Chapter 3: Vision

Age-Related Macular Degeneration

Age-related macular degeneration[92] is the leading cause of irreversible vision impairment for older adults in many countries including the United States and Canada. In its advanced stages it causes a serious loss of central vision[108] including visual acuity[5] impairment and contrast sensitivity impairment[106]. Peripheral vision[109] is not impacted by AMD[117] and thus the extent of the visual field[6] for people with AMD is comparable to those without AMD.

Review of Evidence on Driver Safety and Performance With Respect to Age-Related Macular Degeneration (AMD, ARM or ARMD)

Driver Safety:
A recent review of the literature on AMD and driving indicated that little to nothing is known about the safety of drivers with AMD. As mentioned above, advanced AMD can cause serious visual acuity impairment, so the reader is referred to the section on visual acuity impairment for guidance on this functional impairment.

Driver Performance:
A recent review of the literature on AMD and driving performance indicated that little to nothing is known about driving performance in people with AMD. As mentioned above, advanced AMD can cause serious visual acuity impairment, so the reader is referred to the section on visual acuity impairment for guidance on this functional impairment.

Reference Number	Compete Citation (With Quality of Evidence)
1	Owsley, C., & McGwin Jr., G. (2008) Driving and Age-Related Macular Degeneration. Journal of Vision Impairment and Blindness, 14, in press. [overview]

Other Considerations:
It is important to keep in mind that AMD has a wide spectrum of disease severity, and simply because a person has AMD does not mean that they have serious vision impairment. In the early phases of AMD, visual acuity is often within normal range and would meet the vision standard in most jurisdictions. Even in the intermediate stages of AMD, good visual acuity or only moderate impairments can occur. Thus, it is important to emphasize that drivers with AMD should not be stigmatized as having seriously impaired visual acuity, when in fact for many of these drivers, this will not be the case.

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:
Visual acuity[5] can be seriously impaired in the intermediate to advanced stages of AMD[117], although there is considerable variability in what level of acuity impairment manifests itself in a given person. Thus, simply because a person has intermediate or advanced AMD does not mean that the person should be denied licensure. They, like all driver applicants, should be evaluated with the visual acuity screening test and appropriate road tests used by their jurisdiction.

Chapter 3: Vision

Cataract

Cataract[93] refers to an increased opacification[118] of the lens in the eye. In other words, the lens becomes cloudy thus causing objects and patterns to look washed out, blurry, and/or indistinct. The most common form of cataracts, by far, is age-related cataracts that occur in the later decades of life. Age-related cataracts do not come on suddenly but typically develop over a period of years. Cataracts cause vision impairment, especially visual acuity[5] and contrast sensitivity impairment[106]. Cataracts are highly treatable in that vision impairment can be substantially reversed by surgical cataract removal and intraocular lens insertion (typically an outpatient procedure).

Review of Evidence on Driver Safety and Performance With Respect to Cataract:

Driver Safety:

Cataracts that are clinically significant and causing vision impairment are associated with a history of crash involvement [1]. Furthermore, older adults with cataracts who underwent surgery had a rate of crash involvement that was 50 percent lower than older adults with cataracts who did not undergo surgery [2]. It appears that contrast sensitivity impairment underlies the increased crash risk in older drivers with cataracts [3].

Driver Performance:

A study evaluated driving performance before and after second-eye cataract surgery and found that driving performance significantly improved following cataract surgery and the degree of improvement was associated with the degree of improvement in contrast sensitivity[25] [4].

Reference Number	Compete Citation (With Quality of Evidence)
1	Owsley, C., et al., (1999). Older Drivers and Cataract. Driving Habits and Crash Risk. Journal of Gerontology: Medical Sciences, 54A:M203-M211. [moderate]
2	Owsley, C., et al., (2001). Visual Risk Factors for Crash Involvement in Older Drivers With Cataract. Archives of Ophthalmology, 119:881-887. [moderate]
3	Owsley, C., et al., (2002). Impact of Cataract Surgery on Motor Vehicle Crash Involvement by Older Adults. JAMA, 288:841-849. [moderate]
4	Wood, J. M., & Carberry, T. P. (2006). Bilateral Cataract Surgery and Driving Performance. British Journal of Ophthalmology, 90:1277-1280. [moderate]

Other Considerations:

Cataract[93] has a wide range of severity, and in its earliest phases may not noticeably impair vision. When cataracts develop to the point of impairing vision and interfering with the person's performance of the visual activities of daily living, health insurance (including Medicare) typically covers the cost of surgical removal and intraocular lens insertion in order to reverse vision impairment (typically an outpatient procedure). Thus, cataracts are a highly

treatable condition. If a person with significant, vision-impairing cataracts would like to maintain licensure and the ability to drive safely, cataract surgery is considered for most of these individuals to be an effective treatment option for both improving vision and enhancing driver safety.

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:

A diagnosis of cataract per se should not preclude licensure. However, when clinically significant cataracts are present, contrast sensitivity[25] is typically seriously impaired, as is visual acuity[5]. When contrast sensitivity or visual acuity impairment due to cataract becomes severe, the driver in consultation with their ophthalmologist should consider any potential benefits that cataract surgery might have for improved driver safety. See also recommendation under visual acuity impairment and contrast sensitivity impairment.

Chapter 3: Vision

Glaucoma

Glaucoma[95] is a leading cause of irreversible vision impairment in many countries including the United States and Canada. Glaucoma, a disease where the optic nerve degenerates, causes visual field impairment[110] and in its advanced stages can also lead to loss of central vision[108] including impaired visual acuity[5] and contrast sensitivity[25]. Increased pressure inside the eye is a common characteristic of glaucoma, although one can have glaucoma but not have high eye pressure. Glaucoma can occur at any age but is more common among adults age 40 or older.

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

Driver Safety:

One study did find that self-reported glaucoma (rather than that diagnosed in a medical record) was associated with increased crash involvement, although it is important to point out that self-reports of conditions such as glaucoma can be quite unreliable [1]. A recent study showed that having a diagnosis of glaucoma in the medical record was not associated with crash involvement [2]. However, among those who have glaucoma, moderate to severe visual field impairment can elevate crash risk, particularly if the field loss is in both eyes [3, 4].

Driver Performance:

There are only a small number of studies on driving performance by people with glaucoma. One study examined on-road driving performance in a sample of drivers with visual field loss due to glaucoma [5]. These drivers did not have severe field loss, but minor to moderate binocular visual field loss (i.e., horizontal field ranging from 78 to 165 degrees). They displayed acceptable on-road driving skills. Another study [6] examined on-road driving performance in drivers with minor to moderate field loss and also found that these drivers performed most driving skills appropriately. However, the study also reported that they were more likely to have difficulties in seeing peripheral hazards than did drivers with normal visual fields.

Reference Number	Compete Citation [with quality of evidence]
1	Hu, P. S., et al., (1998). Crash Risks of Older Drivers: A Panel Data Analysis. Accident Analysis & Prevention, 30:569-581.
2	McGwin Jr., G., et al., (2004). Is Glaucoma Associated With Motor Vehicle Collision Involvement and Driving Avoidance? Investigative Ophthalmology & Visual Science, 45:3934-3939. [moderate]
3	McGwin Jr., G. (2005). Visual Field Defects and the Risk of Motor Vehicle Collisions Among Persons With Glaucoma. Investigative Ophthalmology and Visual Science, 46:4437-4441. [moderate]
4	Haymes, S. A., et al., (2007). Risk of Falls and Motor Vehicle Collisions in Glaucoma. Investigative Ophthalmology and Visual Science, 48:1149-1155. [moderate]
5	Bowers, A., et al., (2005). On-Road Driving with Moderate Visual Field Loss.

	Optometry & Vision Science, 82:657-667. [moderate]
6	Haymes, S. A., et al., (2008). Glaucoma and On-Road Driving Performance. Investigative Ophthalmology and Visual Science, 49:3035-3041. [moderate]

Other Considerations:

It is important to keep in mind that glaucoma[95] has a wide spectrum of disease severity, and simply because a person has glaucoma does not mean the person has a serious visual field impairment[110]. In the early phases of glaucoma[95], visual field impairment is often minor and only in one eye, and the horizontal visual field[6] for both eyes together would meet the vision standard in most jurisdictions. Thus, it is important to emphasize that drivers with glaucoma should not be stigmatized as having seriously impaired visual fields when in fact for many of them this will not be the case.

There is a great deal of variability in the driving performance of people with glaucoma who have visual field impairment. Although research has not yet addressed this issue, the more successful drivers may be using scanning strategies to compensate for visual field loss. This suggests that some drivers with glaucoma who are having driving difficulties could benefit from rehabilitation programs that teach these strategies.

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:

A diagnosis of glaucoma[95] per se should not preclude licensure. Serious visual field impairment[110] in both eyes from glaucoma is likely to elevate crash risk. However, how serious field impairment should be defined and where the cut point should be cannot be determined from existing research. As discussed in the visual field impairment section, a fair 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. Based on this information (and any other information required by the jurisdiction), the jurisdiction could then make a decision about licensure.

Chapter 3: Vision

Diabetic Retinopathy

Diabetic retinopathy[98] is a vascular complication of both type 1 and type 2 diabetes where blood vessels in the eye swell and leak or abnormal new blood vessels grow. (For more information on diabetes see page 72.) There are several stages of diabetic retinopathy, and vision can range from relatively normal to severely impaired. Diabetic retinopathy can impair vision in several different ways, including causing impairments in visual acuity[5], contrast sensitivity[25] and/or visual field[6]. Good control of blood sugar decreases the risk for vision loss from diabetic retinopathy.

Review of Evidence on Driver Safety and Performance With Respect to Diabetic Retinopathy

Driver Safety:
There have been no studies on diabetic retinopathy and crash involvement.

Driver Performance:
There have been no studies on diabetic retinopathy and driving performance.

Other Considerations:
See section on diabetes for a discussion of this issue.

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:
Visual acuity and the visual fields can be seriously impaired in diabetic retinopathy, although there is considerable variability in what levels of acuity and visual field impairment[110] manifests itself in a given person. Thus, simply because a person has diabetic retinopathy does not mean that the person should be denied licensure. They, like all driver applicants, should be evaluated with the vision screening tests used by their jurisdictions.

Chapter 4: Medical Conditions

Introduction

This chapter groups together the most common medical conditions associated with increased driver risk. These conditions differ from the previous chapters in that they may not lend themselves to on-road assessment. The episodic nature of epilepsy and diabetes mean that there may not be any functional limitations between episodes of total or partial incapacity. However, the evolutive nature of most of these conditions means that functional limitations may occur that could require functional evaluation. Each case will require individual assessment to determine the appropriate means of evaluation.

Dementia

Dementia[7] is impairment in short-term and long-term memory, associated with impairment in abstract thinking, impaired judgment, other disturbances of higher cortical function, or personality change. The disturbance is severe enough to interfere significantly with work, usual social activities or relationships with others. The diagnosis of dementia is not made if these symptoms occur in delirium[119]. Among the many causes of dementia, the neurodegenerative disorder[120] Alzheimer's disease[12] is the most common and vascular dementia (caused by strokes[23]) is the next most common. Other neurodegenerative causes of dementia include Parkinson's disease[58], brain tumors, trauma, and chronic alcoholism. Multiple sclerosis[54] sometimes causes dementia as can brain infections including viral encephalitis[121], late-stage syphilis[122], and HIV/AIDS[123] as well as other rare disorders. Metabolic[124] causes of dementia include hypothyroidism[125], and Vitamin B12 and other vitamin deficiencies and poisons, such as heavy metal (e.g., lead) poisoning. In mild cognitive impairment, older individuals demonstrate cognitive impairments that are greater than those expected with normal aging, but are not sufficient to diagnose dementia. Cognitive impairments in dementia can reduce driver performance and increase the risk of driver errors that can lead to a vehicle crash. Based on population aging trends, the number of individuals who meet the criteria for dementia is expected to triple by mid-century, with clear implications for driving risk.

Review of Evidence on Driver Safety and Performance With Respect to Dementia:

Driver Safety: To maintain their autonomy, individuals may be encouraged to continue to drive until they meet some societal or legal criteria for unsafe driving. Risk assessment depends on driver competence and the amount and type of driving exposure. Private clinicians do not directly measure driving competence and must infer it from demographic, historical and cognitive measures, but these estimates may disagree with direct clinical and behind the wheel assessments of occupational therapists or driving rehabilitation professionals.

Driver Safety Continued: Evidence of linkages between cognitive abilities measured by neuropsychological[75] tasks and driving behavior assessed using driving simulators, road tests, and State crash records can help standardize the assessment of fitness-to-drive.

Driver Performance: There is consensus that suspicion of the possibility of a diagnosis of dementia should immediately trigger a functional evaluation of the driver's fitness to drive. Some experts go so far as to suggest that any cognitive deficit, particularly a newly observed deficit, should also trigger a functional evaluation.

Although there is unanimous agreement that severe dementia is incompatible with safe driving, precluding the requirement for a functional evaluation, the cognitive deficiencies in mild and moderate dementia are so varied that predicting on-road driving performance on the basis of the results of the various tests used to evaluate cognitive defects is impossible.

Self-awareness/insight and judgment are vital to safe driving but are difficult to measure in cognitive tests. Even when the off-road examiner can identify problems with insight and judgment it is still not easy to predict driver performance. Consequently, except in the most extreme cases, which should probably be classified as severe rather than moderate dementia[7], the road test is an integral part of the functional evaluation of driving skills.

A number of tests have been identified as useful in predicting driver performance. Useful Field of View[232] (UFOV[233]), Trail Making A and B[26], and similar tests are useful in identifying drivers who may perform badly on road tests. Unfortunately, the predictive power of these tests is not sufficient for licensing decisions to be based solely on the results of these and similar tests.

The Mini Mental Status Exam[27] (MMSE[28]), or Folstein test, is a screening tool useful in identifying people with a cognitive problem that requires further assessment. Although it has some predictive value as far as on-road performance is concerned, it cannot be used to exclude the person from holding a driver's license.

A score of 24/30 or less on the MMSE equates to a 70-percent chance of failure on the road test and a score of 19/30 to a 95-percent failure rate. However, a score of 24 also equates to 30-percent chance of success and no method of identifying into which group a particular individual will fall has yet been devised. Consequently, an MMSE score, by itself, is insufficient to justify suspension of a driver's license.

Even a score of 30/30 on the MMSE does not preclude the chance of failure on the road-test. Since the MMSE does not evaluate insight or judgment, deficiencies in these areas are possible with such a result.

The bottom line is that the health care professional who suspects a cognitive problem, no matter what the MMSE result, should insist upon a functional assessment. The same is true when the MMSE result is abnormal. Ideally health care professionals would detect the potentially compromised patient before there is a road-safety-related incident. Unfortunately, this is not the case, partly because most health professionals have little knowledge or awareness of the road safety implications of many medical conditions, including mild dementia. However, the diagnosis of dementia can be difficult and the first sign of cognitive problems may be the incident at the wheel.

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:
1. Applicants with a clinical diagnosis or history of dementia[7] who seek a license to drive a motor vehicle should be examined and certified for functional ability at periodic intervals by a qualified clinician with appropriate neurological[32] training and expertise. Neuropsychological[75] assessment may also be needed.

2. DMVs[4] may be able to screen for drivers who need neurological examination by observation, interview, and questionnaire. In addition, DMV personnel may be able to apply simple screening tools (e.g., MMSE[28], Trail Making Test[26]). Criteria for triggering referral for neurological assessment could include at least two of the following:

(1) Age 80 years old or greater;
(2) History of a recent crash or moving violation;
(3) Applicant self-report or caregiver report of impaired skills;
(4) Use of psychoactive medications[126] such as benzodiazepines[127], neuroleptics[128], antidepressants[129], or use of medications for Alzheimer's disease[130] (AD[131]);
(5) History of active alcohol abuse;
(6) History of falls;
(7) Inability to understand or hear instructions during interactions with the DMV[4] examiner or the health professional;
(8) Scores with simple screening tools that indicate the possibility of a cognitive deficit; or
(9) Inability to complete the DMV knowledge test.

3. Applicants must present themselves for a neurological or neuropsychological evaluation when directed by their State DMVs, and submit a copy of the clinician's report to the DMV at the time of the recertification.

4. Medical assessments of drivers with possible dementia must include results of screening tests, such as the MMSE or Clinical Dementia rating scale[132] (CDR[133]). An MMSE score of less than 24 is generally, but not absolutely, correlated with unsafe driving. Drivers with scores of 17 and below are probably (but not always) unsafe to drive. Applicants with a MMSE of 17 or below (reflecting moderate dementia) who are certified to drive should possibly be reconsidered for re-evaluation for driving competence at 6-month intervals.

5. A driver who is identified as having a cognitive problem may be required to undergo certain tests that will evaluate problems associated with driving. The primary test is the on-road evaluation but there are tests that are administered in an off-road setting that are also used to evaluate certain cognitive functions necessary for safe driving. These evaluations may be conducted by the DMV[4], occupational therapists, or driving rehabilitation specialists. Many jurisdictions will not issue a conditional driver's license to someone with dementia[7].

6. As a group, patients with CDR[133] of 0.5-1 should probably be considered to be at higher risk for failing an on-road driving test. Patients with a CDR of 1 are at a slightly higher risk than those with CDR 0.5. However, CDR of 0.5-1 patients should probably not be categorically considered to be unsafe, as a substantial percentage can still pass an on-road driving test. Patients with a CDR of 1 (reflecting moderate dementia) should possibly be reconsidered for re-evaluation for driving competence at 6-month intervals.

7. Tests of attention, executive functioning, visuospatial[134] skills, and memory should be applied in neurological[32] assessments of applicants who screen positive for dementia. In Alzheimer's disease[12] there is sufficient evidence to recommend the use of Trails A and B Test[26], the UFOV[233], the Judgment of Line Orientation Test[135] (JLO)[136], the Block Design Test[137], the Benton Visual Retention Test[138] (BVRT)[139], the Complex Figure Test[140] (CFT[141]), and the Facial Recognition Test[142]. In Parkinson's disease[58], there is sufficient evidence to recommend tests of executive functioning, and visuospatial skills for use in driving assessments. There is also evidence to recommend the use of Trails B. In general, scores on these tests that are compatible with moderate dementia should be considered as predictive of unsafe driving. Drivers who show unawareness of cognitive impairment should not be certified to drive.

8. Applicants with greater numbers of risk factors should be considered at greater risk, although the relative risks are not necessarily additive. Additional factors besides screening and neuropsychological[75] test scores to consider are history of crashes, applicant self-report of fair skills, family member or caregiver report of fair skills, applicant habits (self restriction, aggression, impulsivity, and alcohol abuse) and use of psychoactive medications[8] such as benzodiazepines[9], neuroleptics[10], tricyclics[143], narcotic analgesics[144].

9. In dementing disorders in which we do not have sufficient evidence to draw statistical conclusions on driver safety, it is reasonable to apply the same safety standards as for applicants with Alzheimer's disease until proven otherwise (even if different tests may have differential predictive validity for different types of dementia).

10. Applicants with dementia must be capable of providing informed consent in order to be considered for certification to drive. The applicants should be judged on if they are able to comply with all medical therapy (e.g., blood pressure medications, diabetes[15] medication, dopaminergic medications[145], spectacles, hearing aids) and unlikely to have reduced driving ability due to complications affecting other systems (e.g., vision, auditory, cardiovascular, psychiatric) mediating abilities that are critical to safely operating a motor vehicle. They must present themselves for neurological or neuropsychological evaluations when directed by their State licensing authority, and submit a copy of the neurological report to the DMV at the time of the recertification.

11. Driver training programs should be considered, but there is no evidence as yet that they work in dementia[7], and completion of driver training or education is not a factor in recertification.

12. There is insufficient evidence to recommend countermeasures such as restricted driver licenses in drivers with dementia. There is concern among some experts that issueing

restricted licenses to individuals with dementia may falsely give the impression that they are deemed safe to drive, when in fact, they are deemed not safe without the restrictions.

13. The practice of "co-piloting," or having another individual guide a driver with dementia through the driving task should be strongly discouraged by health care professionals. DMVs should not issue restricted licenses that are contingent on a driver with dementia having a passenger.

14. Adjudication of cases in which an individual is deemed unlikely to be fit to drive by a certified neurological[32] practitioner, in which the individual insists on further deliberation of driving privileges, should be made by the DMV[4], including consideration of a road test.

References:

Evidence is graded as Class 1 [high], Class 2 [moderate] or Class 3 ["low"]

Dubinsky, R. M., Stein, A. C., & Lyons, K. (2000). Risk of driving and Alzheimer's disease. Neurology, 54:2205-2211

Zador, P., Krawchuck, S., & Voas, R. (2000). Alcohol-related relative risk of driver fatalities and driver involvement in fatal crashes in relation to driver age and gender: an update using 1996 data. Journal of Studies on Alcohol, 61:387-95.

Evidence:

1. <u>Effects of Aging on Driving Competence</u>

In a prospective study, driver's age > 78 increased the odds of future crashes in the next 4 to 5 years (OR 1.26 (1.01, 1.57), multivariate regression) (Ball, 2006). In a DMV study, increasing age correlated with poorer performance on a test to resume driving (OR not available) (Janke, 1998). In a longitudinal study of drivers with aging and AD[13], the Cox proportional hazard ratio of driving cessation increased over a year (HR: 1.06 (1.02, 1.09) (Duchek, 2003)

Class 2 studies gave mixed results. Three studies used an on-the-road test: one study of normal drivers found that older drivers made fewer errors (Carr, 1992). Age did not differ between fit and unfit drivers with PD[64] or AD[13] and elderly controls (Grace, 2005). In the third, age (corrected for MMSE[28]) correlated with driving score (0-3) worsened with age (Pearson's r = -0.43) (Odenheimer, 1994).

In a 5-year study of community-dwelling aging drivers (7.3% with possible cognitive impairment), increasing age predicted driving cessation at the next yearly assessment (Antsey, 2006). The OR for each 1-year increase in age in the second year was OR 1.11, (95% CI 1.02,1.20); third year OR 1.21, (1.13,1.31); fourth year OR 1.19, (1.13,1.26); but was not significant for the fifth year. In a survey study of older nondemented drivers renewing their licenses, increasing age predicted health status ($r2$ = 0.19), driving avoidance ($r2$ = 0.19) and driving exposure ($r2$ = -0.22) (Vance, 2006). In a Class 2 study, increasing age in the control group correlated with poorer performance in an on-the-road test (r = 0.45) (Whelihan, 2005).

Two Class 3 studies found that increasing age decreased the odds of continuing to drive. (Adler, 2003; Foley, 2000). In the three studies using governmental crash data, crash rates per million vehicle miles of travel were greater for youngest and the oldest drivers than for middle-age drivers (16 and 11 versus 4) (Kim, 1998; Langford, 2006; Li, 2003). Drivers > 75 years old had a greater proportion of crashes involving judgment errors at intersections (Langford, 2006). A simulator study found increasing age was poorly associated with failure rate (Di Stefano, 2003). One study found that older drivers exhibited more flexibility in route-finding and confidence in their route-finding abilities during a computerized route-finding task with continuous traffic updates (Walker, 1997). Comment: Age alone probably does not predict crash risk. Increasing age is associated with more driving errors, more crashes, and future driving cessation (classes 1-3). Yet older drivers also decrease their driving exposure, with some mitigation of driving risk (classes 2, 3). Increasing age is probably not an independent risk factor for decreased competence.

2. Relationship Between Global Measures of Dementia[7] Severity and Driving Competence

(a) Mini Mental Status Exam[27] (MMSE[28])

MMSE score and on-road driving test performance tend not to correlate unless a study population includes MMSE scores < 24. For example, in one Class 2 case control study (Odenheimer, 1994) where the mean MMSE score for cases was 14.8, there was a significant correlation ($r = .72$, $p<0.01$). Another Class 2 study (Fitten, 1995) demonstrated a correlation ($r = 0.63$) for those with MMSE scores < 24; above 24, there was no correlation. When the study population is primarily or exclusively those with MMSE scores greater than 24, two Class 2 studies (DeRaedt, 2001a, Grace, 2005) failed to demonstrate correlations with on-road driving test scores. In a Class 3 study (Johannsen, 1996), 78 percent of suspended drivers had an MMSE score above 25. An MMSE score of less than 24, however, does not completely correlate with unsafe driving. In a Class 2 study (Kantos, 2004), when patients with scores less than 24 and co-morbid conditions (e.g., slow reaction times, visual problems) were excluded, a score of less than 24 did not significantly increase the odds of failing (OR 1.20, 0.73-20). Comment: MMSE scores of 24 or above should probably not be considered to be sensitive in discriminating between safe and unsafe drivers. An MMSE score of less than 24 is generally, but not absolutely, correlated with unsafe driving. Drivers with scores of 17 and below are probably, but not always, unsafe to drive.

b) Clinical Dementia Rating Scale[132] (CDR[133])

One Class 1 and three Class 2 studies analyzed on-road driving test performance and CDR scores. In the Class 1 study (Brown, 2005), compared to drivers with CDR 0, the RR for unsafe driving for those with CDR 0.5 was 82.7 (5.1, 1333); for CDR 1 vs. 0, the RR was 88.67 (5.4, 1444). Yet, 46 percent of the CDR 0.5 group and 41 percent of the CDR 1 group passed the test, compared to 84 percent of controls.

The first Class 2 study (Hunt, 1997) found that drivers with a CDR of 0.5 had a RR of 9.67 (2.3, 40.7) for being judged unsafe in a comparison to drivers with a CDR of 0, drivers with CDR of 1 had an RR was 12 (2.8, 50.1). However 67 percent of the CDR 0.5 group and 41 percent of the CDR 1 group still passed the test, versus 78 percent of controls.

In the second study (Duchek, 2003), drivers with CDR[133] of 1 were more likely to be judged unsafe on 6-month follow-up on-road driving tests than drivers with a CDR of 0 (RR 2.68 vs.

(1.4, 4.8); NS for CDR of 0.5 vs. 0 and CDR 1 vs. 0.5). In the third study (Grace, 2005), the RR for unsafe driving of drivers with CDR of 0.5 or 1 vs. CDR 0 was 25 (1.5 – 384). A substantial percentage (45%) of CDR 0.5-1 drivers passed the test. Comment: Individuals with CDR of 0.5-1 should probably be considered to be at higher risk for failing an on-road driving test (RR range 9.67 – 88.67). Those with CDR of 1 are at a slightly higher risk than those with CDR 0.5. However, CDR of 0.5-1 patients should probably not be categorically considered to be unsafe, as a substantial percentage (41% - 67%) can still pass an on-road driving test. Patients with a CDR of 1 should possibly be reconsidered for re-evaluation for driving competence at 6-month intervals.

3. Neuropsychological[75] Prediction of Driving Safety

Evidence is summarized by cognitive domain as in Lezak (2004) and Strauss, Sherman and Spreen (2006) and for different diseases because different neuropsychological tests may have differential predictive validity for different types of dementia[7].

a) Attention and Concentration

Alzheimer's disease[12]

UFOV: The Useful Field of View[232] test depends on speed of processing and attention subtests. Uc et al., 2004 reported that the total UFOV score (sum of the four UFOV subtests) correlated significantly with incorrect turns (r = .42), times lost (r = .23), and at-fault safety errors (r = .25) on a road test (Class 1). UFOV total score was associated with incorrect turns in several adjusted and unadjusted regression analyses. Rizzo et al., (1997) reported that UFOV total loss greater than 50 percent predicted crashes during a simulated driving scenario (OR = 18.13, CI = 2.34, ∞). The association was no longer significant in a stepwise logistic regression with other tests. In a Class 2 study (Uc et al, 2006) UFOV was associated with abrupt slowing (OR = 1.20, CI = 1.05, 1.37), but not crash or risky behavior, or premature stopping (Class 2). The association with abrupt slowing remained significant after adjusting for diagnosis. UFOV total loss > 50 percent was not associated with crash in another Class 2 study of simulated driving (Rizzo et al., 2001). *Trails A*[26]*:* Trails A was evaluated in 4 Class 2 studies. Of the three studies that examined road test outcomes, one reported a difference in Trails A scores between safe and unsafe drivers with AD[13] (mean+SD = 41.22+17.29 and 106.63+56.09 for safe and unsafe, respectively) (Grace, 2005), and one reported a significant correlation between Trails A and a pass-fail road test outcome among control subjects and participants with AD (τ = .344, p = .02) (Hunt et al., 1993). The third road test study reported no significant relationship (Fox, 1997). A simulator study (Uc et al., 2006) reported an association between Trails A and abrupt slowing (OR = 1.02, CI = 1.01, 1.04), but not two other driving outcomes.

Digit Symbol: Two Class 2 studies reported conflicting results. The first reported a significant correlation between this cognitive test and a pass-fail driving outcome among adults with AD[13] and healthy older controls (r = -.39, p = .007; Hunt et al., 1993). However, another study found no correlation between Digit Symbol performance and a total driving score or a pass-fail driving outcome among subjects with probable AD (Fox et al., 1997). *Digit Span:* Rizzo et al., (1997) suggested that an age-corrected score <10 (forward plus backward) predicted simulated car crashes among subjects with AD and controls without dementia[7] (OR = 10.04, CI = 1.31, ∞). A Class 2 study, by the same team, failed to replicate this finding when Digit Span was used to predict simulated intersection crashes (OR = 6.58, CI = .60, 354.77; Rizzo et al., 2001).

Parkinson's disease[58]

Trails A[26]*:* Non-demented patients with mild to moderate PD[64] completed a neuropsychological[75] battery, including Trails A and a standardized road test (Grace, 2005). There was no difference between safe and unsafe drivers with PD on Trails A (Class 2). In a second Class 2 study (Stolwyk et al., 2006), Trails A correlated with only one of six simulated driving outcome measures (meters traveled past traffic signals) among 18 participants with PD ($r = .49$, $p<.05$).

Choice reaction time: One study failed to detect a relationship between a choice reaction time test and simulated driving outcomes (Stolwyk et al., 2006). In a second study, correct responses on a choice reaction time test correlated with number of road test faults ($r = -.56$, $p<.01$), but not number of road test offenses in a sample of patients with PD (Heikkila et al., 1998; Class 3). Decision time on the task correlated with both faults and offenses, but choice reaction time was not an independent predictor of road test errors.

Paced Auditory Serial Addition Task[146] *(PASAT*[147]*): (*Radford et al, 2004, Class 2), found no relationship between the PASAT and road test performance. In a second study, PASAT correlated with road test speed ($r = .32$, $p = .01$) and speed variability ($r = -.27$, $p = .03$) among mild to moderate PD patients (Uc et al., 2006; Class 1). However, PASAT was not a significant independent predictor of driving performance.

Dementia[7]***/Suspected Dementia***

Several studies examined samples that combined patients with several types of dementia, or did not describe or assess specific diagnoses in groups with suspected dementia. Since this data may supplement research reviewed above for specific diagnostic groups, all relevant studies are described.

Trails A: In a Class 2 driving simulator study (Szlyk et al., 2002), Trails A correlated with lane boundary crossing ($r = .73$, $p = .0001$), Speed ($r = -.57$, $p = .009$), and brake pedal pressure, calculated as the SD of pressure during the session ($r = -.61$, $p = .01$; Class 2). In a Class 3 study of patients with mild dementia (CDR = 0.5), Trails A did not correlate the road test score (Class 3). In another Class 3 study of older and dementia patients (Odenheimer et al, 1994), Trails A correlated with the in-traffic road test score in the whole sample ($r = .52$, $p < .01$; age adjusted, $r = .33$, $p < .05$). In a battery of tests used to predict fitness to drive (based on a road test), Trails A made a significant contribution to the model ($p = .005$; de Raedt et al., 2001a) and the test battery's combined test score of 24 out of 30 (including Trails A, MMSE[28], the Clock Test, age, and visual acuity) demonstrated a sensitivity of .80 and a specificity of .85.

Other tests: Complex reaction time also correlated with in-traffic score in a Class 2 study (Odenheimer et al., 1994; $r = -.70$, $p < .01$; $r = -.58$, $p < .01$), while simple reaction time did not correlate. UFOV[233] and Letter Cancellation were examined by Whelihan et al., (2005; Class 2). All three UFOV subtests administered correlated with the road test score in the patient group (r's .46 to .61, p's < .05). There was no relationship between Letter Cancellation and the road test score. A Class 1 study examined the Sternberg Test, an adapted version of the Mackworth clock, and a visual tracking test in relation to a road test in several dementia[7] and control groups (Fitten et al., 1995). Drive score correlated with the Sternberg ($r = .71$) and Mackworth clock ($r = -.52$) tests. In a stepwise multiple regression, the Sternberg test, visual tracking and one other test (MMSE[28]) best correlated with drive

score. In a Class 2 simulator study (Szylk, 2002), Digit Span correlated with brake pedal pressure (r = .48, p = .04), but not lane boundary crossing or speed. Digit Symbol correlated with lane boundary crossing (r = -.47, p = .03), but not the other two driving outcomes. In a Class 3 study (Cushman, 1992), low scores on a sustained attention task (vigilance) discriminated between drivers who met or failed a road test (t = -3.26, p =.008).

b) Executive Functioning

Alzheimer's disease[12]

Trails B[26]*:* Trails B was administered in two Class 1 studies and four Class 2 studies that included subjects with Alzheimer's disease. All but one Class 2 study (Fox, 1997) reported a significant association between Trails B performance and driving outcomes. Rizzo et al (1997) found an association between impaired Trails performance (scaled score equivalent < 3; < 1 percentile) and crashes during simulated driving (OR = 30.19, CI = 3.81, ∞). Uc et al., (2004) reported significant correlations between Trails B performance and both incorrect turns (r = .27, p < .001) and at-fault safety errors (r = .19, p = .01) on a road test (Class 1). Neither study identified Trails B as a significant predictor in stepwise logistic regressions.

In Class 2 studies, Trails B discriminated between safe and unsafe drivers on a road test (184.55+94.00 and 289.91+24.42 sec respectively) (Grace, 2005), predicted simulated driving crashes (Trails B scaled score equivalent <3, < 1st percentile; OR = 13.47, CI = 1.19, 747.68) (Rizzo et al., 2001), and predicted abrupt slowing (OR = 1.31, CI = 1.12, 1.54), premature slowing (OR = 1.17, CI = 1.02, 1.35), and crash or risky behavior (OR = 1.22, CI = 1.01, 1.46) during simulated driving (Uc, 2006). However, in the latter study, these tests demonstrated no additive predictive value beyond diagnosis. *Controlled Oral Word Association*[148] *(COWA*[149]*):* Two Class 1 studies and three Class 2 studies examined the COWA. Scores less than 30 (corrected for age and education) were associated with crashes during simulated driving (OR = 24.56, CI = 2.16, 1373.29; Class 1; Rizzo, 1997). Results were mixed in a second Class 1 study; COWA correlated with incorrect turns on a road test (r = -0.21, p = .005), but not times lost or at-fault errors (Uc, 2006). Evidence was also mixed in Class 2 studies. Rizzo et al. reported a significant association with crashes during simulated driving (COWA < 30; OR = 41.68, CI = 3.02, 2716.06), but Uc et al (2006) did not find an association with road test outcomes.

Parkinson's disease[58]

Trails B[26]*:* Four Class 2 studies examined executive functioning with Trails B, and all reported significant associations with driving performance. Trails B discriminated between safe and unsafe drivers with PD[64] (142.55+79.88 and 214.57+89.14 sec, respectively) (Grace, 2005; Class 2), and Trails B performance correlated with four of six simulated driving outcomes in a second study (r's = -.44 to -.50) (Stolwyk et al., 2006). Trails B scores (adjusted for Trails A) correlated with road test speed (r = -.35, p = .005), speed variability (r = .37, p = .003), and steering variability (r = -.28, p = .03) among mild to moderate PD patients (Uc et al., 2006). An additional study also demonstrated a correlation between simulated driving performance and Trails B (r = .48; p<0.01) (Zesiewicz et al., 2002).
Stroop: In one Class 2 study Stroop interference scores did not differentiate between safe and unsafe drivers with PD (Radford, 2004).

Suspected/Other Dementia[7]

In one Class 2 study of patients with Huntington's disease[150] (Rebok et al., 1995), scores on the Stroop, Wisconsin Card Sorting Test[151] (WCST[152]), and Trails B did not correlate with simulated driving performance. One Class 1 study (Cushman, 1992), two Class 2 studies

(Szlyk, 2002; Whelihan, 2005) provided additional support for Trails B. Similarly mazes were supported in one Class 2 study and one Class 3 study. Maze navigation time correlated with road test performance ($r = .52$, $p < .01$) but not maze errors in a second study (Class 2; Whelihan, 2005). Maze errors (OR = 15.51, $P < .001$) and maze completion time (OR = 5.87, $p < .01$) were both associated with road test pass-fail scores. In one Class 3 study, there was a significant difference between dementia patients with and without crashes on Category Naming (Lucas-Blaustein, 1988).

Alzheimer's disease[12]

Line Orientation[135]*:* Judgment of line orientation was examined in two Class 2 articles. Uc et al. found that line orientation correlated significantly with landmark and traffic sign identification ($r= 0.25$; $p=0.0009$) Rebok et al. found that line orientation correlated significantly with hazard reaction time($r= 0.23$).

Block Design[137]*:* Block design was examined in two Class 2 articles. Uc et al. found that block design correlated significantly landmark and traffic sign identification ($r=0.4$; $p<0.0001$) and at fault safety errors ($r= -0.24$; $p=0.0022$). Rizzo et al. found that block design correlated significantly with simulator performance (OR= 40.78; CI= 3.29, 2441.41; $p<0.001$). Benton Visual Retention Test[138] (BVRT[139]): The BVRT was examined in one Class 1 article. Hunt (1993) found that BVRT-Copy (Form D) (mean 9.2, SD = 1.5) correlated significantly with a pass-fail road test ($r= -0.42$; $p=0.008$).

Complex Figure Test[140] *(CFT*[141]*):* CFT was examined in two Class 2 articles. Rizzo et al. found that CFT copy was associated with simulator performance (OR= 57.61; CI= 6.88, ∞; $p<0.001$). Rizzo et al. found that CFT copy (<20) was associated with simulator performance (OR= 9.7; CI= 0.79, 164.99).

Parkinson's disease[58]

Block Design[137]*:* In one Class 2 article (Stolwyk et al., 2006) block design correlated with traffic signal approach speed ($r= -0.502$; $p<0.05$), mean curve speed ($r= 0.556$; $p<0.05$), and variability of within curve lane position ($r= -0.335$).

Line Orientation[135]: Judgment of Line Orientation scores correlated with traffic signal deceleration point ($r= 0.461$; $0.05<p<0.07$), traffic signal stop point ($r= - 0.628$; $p<0.01$), curve direction effect on mean lane position ($r= 0.373$), and variability of within curve lane position (-0.336) (Stolwyk et al., 2006).

*Picture Completion: P*icture completion correlated with traffic signal stop point ($r= -0.502$; $p<0.05$), curve direction effect on mean lane position ($r= 0.284$), and variability of within curve lane position ($r= -0.501$; $p<0.05$) (Stolwyk et al., 2006).

Dementia[7]

Block Design: I one Class 2 article (Szlyk et al., 2002) Block Design correlated with lane boundary crossing ($r= -0.48$; $p<0.05$) and speed ($r= 0.469$; $p<0.05$).

Other Tests: The brief visual memory test- revised[153] (BVMT-R[154]) was found to correlate significantly for the delayed recall ($r= -0.28$), but the BVMT-R total score did not (Whelihan et al., 2005; Class 2).

c) Memory

Alzheimer's disease[12]

Rey Auditory Verbal Learning Test[155] *(AVLT*[156]*):* In a Class 2 article (Uc et al., 2005) AVLT-recall correlated significantly with landmark and traffic sign identification (r= 0.50; p<0.0001) and at fault safety errors (r= -0.28; p<0.0002). BVRT[139] was examined in one Class 1 article and three Class 2 articles. Hunt, (1993) found that BVRT- recall (form C) correlated significantly with pass/fail on a driving test (r= -0.43; p=0.003; Class 1). Rizzo et al., 2001 found that low scores on the BVRT (number correct <4) were associated with simulator performance (OR= 1.95; CI= 0.21, 18.18; Class 2). Rizzo et al., 1997 found that BVRT- correct was associated with simulator performance (OR= 12.3; CI= 1.41, ∞; p=0.01; Class 2.

Facial Recognition[142]*:* Facial recognition was examined in two Class 2 articles. Rizzo et al., 1997 found that facial recognition was associated with car crashes in a driving simulator (OR= 58.53; CI= 4.32, 3784.18; p<0.001).Rizzo et al., 2001 found that facial recognition was associated with simulator performance (OR= 1.24; CI= 0.09, 11.74). Logical memory was examined in one Class 1 and one Class 2 articles. Hunt, (1993) found that logical memory in AD[13] (mean 6.7+4.8) correlated significantly with pass-fail road test performance (r= -0.47; p=0.0009; Class 1). Rebok et al., 1994 found that immediate logical memory (mean in AD = 7.8+5.4] correlated significantly with a driving performance test measuring reaction to hazards (r= 0.32; Class 2).

Visual reproduction: One Class 2 article (Rebok et al., 1994) found that immediate visual reproduction in AD (mean =14+9.4) correlated significantly with a driving performance test measuring reaction to hazards (r= 0.28).

Parkinson's disease[58]

AVLT was examined in one Class 2 article. Uc et al., 2006 found that AVLT correlated significantly with speed variability (r= -0.31; p=0.013)

Suspected Dementia[7]

Logical Memory: A Class 2 article (Szlyk et al., 2002) found that Logical Memory I correlated significantly with simulator performance, specifically, with lane boundary crossing (r= -0.59; p<0.01) and brake pedal pressure (r= 0.66; p<0.01). Szlyk et al. also found that logical memory II correlated significantly with speed (r= 0.50; p<0.05) and brake pedal pressure (r= 0.55; p<0.05) in the same simulator task. Visual memory was examined in one Class 2 and one ungraded (as of now) article. Sleek et al. (2002) found that visual memory I correlated significantly with lane boundary crossing (r= 0.50) in a simulator task. Odenheimer et al. (1994) found that visual memory correlated significantly with anon- traffic driving score (r= 0.54; p<.01).

Comments: Tests of attention, executive functioning, visuospatial[134] skills, and memory are useful to assist in assessments of drivers with Alzheimer's disease[12]. There is sufficient evidence to recommend the use of Trails B[26], UFOV[233], Line Orientation[135], Block Design[137], BVRT-Copy[139] and BVRT-Recall, CFT-Copy[141], Facial Recognition[142], and Logical Memory in assessments of drivers with Alzheimer's disease. For patients with Parkinson's disease[58], there is sufficient evidence to recommend tests of executive functioning, and visuospatial skills for use in driving assessments. There was also evidence to recommend the use of Trails B.

4. Demographic Factors and Driving Risk

(a) Gender

After age 25, men crash about 20 to 30 percent more often than women, but women have crash rates per mile driven about 20 to 30 percent higher than men (Janke, 2003, Ryan, 1998). After 65, four Class 3 studies (Stamatiadis, 1995, 1996; Hakamies-Blomqvist, 1994; Kim, 1998) report women to have a 7.9 percent (Stamatiadis, 1996) to 47 percent (Kim, 1998) higher overall, nonmileage adjusted risk for at-fault crashes than men. In one of these studies (Kim, 1998) (n=69,077), women over 70 were the highest risk group for at-fault crashes. A smaller Class 3 study (Ball, 2005) reported lower odds for women being at-fault (OR=0.59).

Comment: There are no clear indications for increased risk related to gender.

(b) Living Status

A single Class 3 study (Lefrancois, 1997) reported a higher adjusted OR (2.22) for a crash in older people living alone.

Comment: The evidence is limited.

(c) Driver and caregiver assessment of driving competence and risk.

Patients who rate themselves as "poor" or "fair" drivers have usually begun to restrict their driving or have stopped entirely (Hakamies-Blomqvist, 1998). Those who continue to drive with restrictions have a fivefold increased risk of crashes (Class 2) (Lesikar, 2002).
Most who continue to drive rate themselves as "safe" drivers, yet their ratings correlate poorly with actual driving performance (Marottoli, 1998). In a Class 1 study of patients with mild Alzheimer's disease[12] (AD[13]) (CDR[133] 0.5 to 1) (Brown, 2005b), 94 percent of patients rated themselves as "safe," but only 41 percent passed an on-road driving test.

This is a specificity of 10.7 percent for self-rating as "safe." In another Class 1 study of patients with mild AD (Hunt, 1993), all patients who failed the on-road driving test considered themselves to be safe drivers. A third Class 1 study of patients with mild AD (Wild, 2003) also reported significant discrepancies between self-rating as "safe" and on-road driving test performance. Caregiver ratings correlate modestly with on-road driving test performance. A Class 1 study of mild AD patients (Brown, 2005b) reported figures that calculate to a sensitivity of 53 percent and specificity of 71 percent for caregiver ratings of "marginal" or "unsafe." A caregiver rating of "safe" had a sensitivity of 81.8 percent and a specificity of 47.8 percent. A second Class 1 study of mild AD patients (Wild, 2003) reported that, while there was no significant difference between informant ratings and patient performance in most categories of an on-road driving test, informants overrated performance in nearly every category.

Comment: There is a poor correlation between a self-rating of "safe" and on-road driving test performance (three Class 1 studies). One Class 2 study reported a higher incidence of crashes in patients with low self-ratings. One Class 1 study reported that an informant rating of marginal or unsafe more accurately predicts on-road driving test performance than a rating of "safe." In a second Class 1 study, informants' ratings were generally higher than those of the driving instructor, but were not significantly different. Clinicians should not consider a patient or informant rating of "safe" to accurately reflect driving competence. An informant's rating of "marginal" or "unsafe" should be considered to be more reliable (but still

insensitive) than a rating of "safe." A self-rating of "poor" or "fair" probably indicates a higher risk for crashes.

(d) Driving history associated with driving competence or risk

Traffic Citations

Among all elements of the driving history, violations are the best predictor of future crashes (Janke, 2003; Gebers, 1992). After 80, 60 percent of citations are for disregarding traffic signs, improper signaling, or failure to yield (Janke, 2003). In elders, citations are moderately correlated with cognitive impairment (r = 0.4–0.5; McKnight, 1999). Drivers 60 to 69 showed an increase in the RR for a crash of 0.77 per traffic citation; for drivers over 70, the RR was 0.54 per citation (Gebers, 1992). For drivers over 70, two or more convictions result in RR of a motor vehicle crash that exceeds that of any other age group. A Class 1 study (Keall, 2004) of all New Zealand drivers over 80 (n = 39, 318) reported that, among patients with traffic citations in the two years prior to the study, the adjusted OR for a subsequent injury crash in the following two years was 2.16 (95% CI 1.10–4.21, p = 0.025).

The logistic regression model used in this study reported a strong correlation between prior infractions and subsequent crashes (r = 0.768, p = 0.025). Another large Class 1 study of drivers over 65 (n = 426, 408) (Daignault, 2002a) also reported a significant but much weaker correlation between prior convictions in the first three years of the study and State reported crashes in the following three years (B= 0.062 for 65 through 69, 0.088 for age > 80; p < 0.0001). Using an on-road driving test as the outcome measurement, one Class 2 (DiStefano, 2003) and one Class 3 (McKnight, 1999) study of older drivers reported previous convictions to be modestly correlated with failing or scoring lower on the on-road driving test.

Comment: Reported violations are relatively uncommon in older drivers and are predictive of increased driving risk (three Class 1, one Class 2, and one Class 3 study). Because of the correlation between previous violations and poor performance on a driving test or future crashes in drivers over 65, clinicians should obtain a history of traffic violations or other officially reported incidents from a reliable informant. Previous violations, especially multiple violations, are strongly correlated with increased driving risk.

Crashes

In older drivers, previous crashes are strongly correlated with deficits in executive functions, (Daigneault, 2002b) visuospatial[134], and psychomotor capabilities (Lundberg, 1998). Two Class 2 studies reported an association between previous accidents and decreased competence. One study of drivers over 65 (DeRaedt, 2000a) reported a significant correlation between self-reported accidents and lower on-road driving test scores (r = 0.29, p<.007).

Cutoff scores for failing the on-road driving test were not provided. Since self-reported crashes are usually underreported, the correlation with all crashes is probably stronger. A large Class 2 study of drivers over 65 (Daigneault, 2002a, n = 426, 408) reported significant correlations between all reported crashes in the first three years of the study and subsequent crashes in the recent three years (regression coefficient B range 0.092 to 0.771, p<0.0001). Since cognitive status was not reported, it is unknown to what degree this correlation is independent of cognitive status. A Class 1 double cohort study of patients with mild dementia[7] and controls (Fitten, 1995) reported a significant correlation, with all groups combined, between the combination of reported collisions and moving violations per mile driven and lower on-road driving test scores (r = 0.38, p<.02). A history of previous crashes

portends a higher risk of future crashes than does the presence of mild dementia alone. A Class 1 study of drivers 55 to 87 (Owsley, 1998) reported that the relative risk of any crash in the last three years of the study was higher for those with a history of a motor vehicle crash in the previous five years (RR 2.0, 95% C1 1.06 to 3.79, p = .03) than for those with cognitive impairment, as defined by a Mattis Organic Mental Syndrome Screening Examination[157] (MOMSSE[158]) score of greater than 9 (RR 1.17, 95% CI 0.61 to 2.27, p = .63). A Class 2 study of drivers over 65 (McGwin, 2000) reported that the OR for an at-fault motor vehicle crash in the final year of the study was higher for drivers with one or more at-fault crashes in the first four years of the study (OR 2.1, 95% CI 1.5 to 3.0) than for drivers with cognitive impairment, defined as three or more errors on the Short Portable Mental Status Questionnaire[159] (SPMSQ[160]) (OR 0.8, 95% CI 0.5 to 1.4).

A third Class 2 study of drivers over 65 (Foley, 1995) reported that the OR for a future crash was higher for drivers with a crash in the previous two years (OR 2.0; 95% CI 1.1 to 3.7) than it was for drivers with mild cognitive impairment, defined as more than two errors on the SPMSQ (RR 0.6, 95% CI 0.3 to 1.2). The circumstances of a crash differ with age. For older drivers, crashes most often result from the improper execution of a turn (Ryan, 1998, Andre, 1999). For drivers over 70, a Class 2 study (Preussner, 1998) reported that failure to yield at an intersection results in a RR for a crash of 2.94, increasing to 10.62 by 85. In a Class 3 study (Chandraratna, 2003), drivers over 65 had < OR of 1.98 (1.82 to 2.17) for an at-fault crash while turning left at an intersection; above 85, the OR was 8.20 (6.43 to 10.46). Crossing a road had an OR of 1.25 at 65 and 4.44 at 85; unsafe lane changes had an OR of 1.11 at 65 and 4.41 at 85.

Comment: The history of a motor vehicle crash in the previous one to five years is likely to be predictive of reduced driving competence in older patients or patients with dementia[7], as measured by future crashes or on-road driving test performance (one Class 1 and four Class 2 studies). In patients with dementia, one Class 1 study reports an association between previous violations and crashes (combined) and poor performance on an on road driving test. The risk of a motor vehicle crash in the one to three years following assessment is probably two times higher in older patients with a history of a previous motor vehicle crash than in patients with mild dementia alone (one Class 1 and two Class 2 studies). Crashes at intersections appear to be a particular problem. In older patients and in patients with mild dementia, clinicians should consider obtaining a corroborated history of crashes, as previous crashes are correlated with reduced driving competence.

Reduced Mileage

Drivers over 60 begin to reduce their annual driving mileage by about 20 to 30 percent per decade of life, with drivers above 85 averaging 75 miles per week (Dellinger, 2001a). People more likely to reduce their driving exposure include females (Charlton, 2003; Lyman, 2001; Margolis, 2002; Vance, 2006) and those with visual impairment (Lyman, 2001; McGwin, 2000; Stutts, 1998) or functional disability (Campbell, 1993; Marattoli, 1993). These variables were controlled for in all studies cited in this analysis. Patients with mild dementia, as a group, drive less than their age-matched controls (Table 1). Reductions in mileage begin at the earliest stages of dementia, assumedly because the patient or caregiver has evidence or concerns of declining competence. The weighted median weekly mileage is 63.3 for patients with very mild dementia versus 149.9 for controls. Two Class 2 studies (Lyman, 2002; Stutts, 1998) using a cutoff of 3,000 miles per year, or 57 miles per week, also reported that restricted driving was more frequent in cognitively impaired patients (OR's range 1.5 to 3.41).

Decreased exposure itself is not only a surrogate marker for dementia, but represents an independent risk factor for decreased competence. A Class 1 mixed population study (Cushman 96) of people over 55 and patients with mild AD[13] reported that the mean weekly mileage of the group failing the on-road driving test was 64.6 (SD 51) versus 210 (SD 165) for the passing group ($t = -7.22$, $p < .001$). Because the passing and failing groups also had significant differences in cognitive status, mileage and multiple cognitive test scores were added into a stepwise logistic regression model to predict failure of the on-road driving test.

Annual mileage emerged as the only significant predictor of failure (chi square = 12.84, $p = .0003$). A Class 2 study of drivers over 65 reported for unsafe driving (DeRaedt, 2000b) excluded patients with a previous diagnosis of dementia, but included people who were subsequently found in the study to have significant cognitive impairment. Using linear regression analysis, reduced mileage was not significantly correlated with MMSE[28] score ($r = .26$, $p > .12$), but was moderately correlated with worse scores on the on-road driving test (Standardized Beta = 0.281, $t = 3.185$, $p = .002$, $r = 0.334$). One Class 3 study of drivers over 65 reported significant differences in driving exposure, but not MMSE scores, between crash-involved and noncrash-involved drivers (MacGregor, 2001).

The apparently independent correlation between reduced exposure and reduced competence may reflect the deterioration of a skill (driving) that requires practice, or may indicate that reduced exposure is actually a surrogate for dementia[7] severity that is not detected within standard global measures. In either case, reduced exposure emerges beyond standard measures of dementia as an independent predictor of reduced driving competence.

Comment: Patients with mild dementia significantly reduce their driving exposure, with an average exposure of about 60 to 80 miles per week (two Class 2 and four Class 3 studies). In older drivers and drivers with mild dementia, there are significant and independent correlations between reduced exposure and poor performance on an on road driving test (one Class 1, one Class 2, and one Class 3 study). Clinicians addressing driving risk in the older people and in patients with dementia should consider obtaining information on driving exposure. Whether reported mileage rates are accurate is unclear.

Situation Avoidance

Avoidance of particular driving situations, such as driving at night, is associated with some of the same factors as described for reduced mileage—increased age, female gender (Charlton), visual problems, declining health status (Baldock, 2006; Anstey, 2005), previous crashes (Daignaeault, 2002b, Ball, 1998), and awareness of cognitive deficits (Cotrell and Wild, 1999). Two Class 1 (Vance, 2006, Baldock, 2006) and three Class 2 studies (Ball, 1998, Staplin, 2003; Stutts, 1998) of older drivers have reported significant, modest correlations ($r = 0.2$-0.4) between avoidance of driving at night, in the rain, or in heavy traffic, and deficits in visual attention (Baldock, 2006b, Ball, 1998), concentration, and executive function (Staplin, 2003, Stutts, 1998, Vance, 2006). Driving avoidance may be a surrogate marker for these types of cognitive deficits that are correlated with reduced driving competence. A Class 1 mixed-population study of drivers over 60 and medically referred drivers (Baldock, 2006a) found correlations between self-reported avoidance of driving in the rain or at night and failing an on-road driving test ($r = 0.33$ to 0.35, $p < .01$). Cognitive testing was not performed. In a Class 2 study (Lesikar, 2002), drivers who reported changing their driving habits because of safety concerns had a RR of 5.3 (95% CI 0.63 to 44.63) of a crash in the following two years. Driving avoidance is not a completely reliable surrogate for reduced competence,

however. In a Class 1 study (Baldock, 2006b) most drivers reported that they "never" avoided difficult situations, even those with deficits in visual contrast sensitivity[25], processing speed, and visuospatial[134] memory that were severe enough to result in failing an on-road driving test.

In a Class 2 study of older and medically referred drivers (Staplin, 2003), those with substantial cognitive impairment were just as likely to report that they "never" avoided difficult situations as always. Thus, while avoidance is correlated with cognitive deficits and reduced driving competence, the lack of avoidance does not indicate competence.

Comment: There are significant, modest correlations between avoidance of difficult driving situations and cognitive impairment (two Class 1 and three Class 2 studies). There is also a correlation between avoidance and future crashes or failing an on-road driving test (one Class 1 and one Class 2 study). However, cognitively impaired patients are equally likely never to avoid difficult situations (one Class 1 and one Class 2 study). Clinicians should obtain a history of avoidance of driving at night, in the rain, or in heavy traffic. Patients who report "always" avoiding these situations are at higher risk for cognitive impairment that correlates with reduced driving competence. The reporting of "never" avoiding these situations should probably be disregarded, as there is no correlation with competence.

Other Driving Habits
Across all age groups, violations and crashes are associated with aggressive or impulsive behaviors, such as willful disregard of traffic laws or expressed anger at other drivers (Parker, 1995; Simon, 1996; Noyes, 1985). In patients with mild to moderate dementia[7] (mean MMSE[28] = 21.9), a Class 1 study (Herrmann, 2006) reported that agitation and aggression were predictive of a refusal to discontinue driving (HR for driving cessation = 0.54, 95% CI 0.32 to 0.90). In a Class 2 study (Lesikar, 2002); self-reported anger or frustration with other drivers was associated with a higher risk of future crashes. Comment: Clinicians should consider aggressive or impulsive personality characteristics to be associated with increased driving risk.

(e) Interventions to reduce driving risk.
Programs to educate elders about at-risk maneuvers have had variable success. A Class 1 randomized controlled trial[161] (RCT[162]) of drivers over 55 (Bedard, 2004), reported no significant difference in on-road driving test scores between drivers randomized to a driver's education program and a control group. In another Class 1 RCT of visually impaired, cognitively unimpaired, crash-involved drivers over 60 (Owsley, 2003), drivers were randomized to a control group or a driver education program that identified potentially hazardous driving situations (e.g., left turns across traffic, driving alone) and interventions (e.g., make three right turns around the block, use a copilot). By self-report, the driver education group significantly reduced their overall driving exposure to hazardous situations. In a Class 2 study of crash-involved, visually impaired drivers with a MMSE of greater than 23 (Stalvey, 2003), those randomized to an educational program reported a significantly increased awareness of visual impairment and a need to self-regulate their driving. In a Class 3 study of drivers over 59 asked to maintain a daily driving diary for 30 days (Kiernan, 1999), there were significant decreases in self reported dangerous events by the end of the reporting period. In another Class 3 study, (Marshall, 2005) the on-road driving test scores of 628 subjects were analyzed. Of 11 driving elements, cognitive ones (anticipating hazards, observing pedestrians, having proper stopping position) are more predictive of passing or failing an on-road driving test and should be considered as a component of driving assessment

programs. In a Class 3 study of referral and reassessment procedures in 20 people with dementia (Lovell, 2005), routine referral and reassessment after six months were found to be appropriate.

Comment: Clinicians may consider referring older drivers with visual impairment for a targeted education program. Safety benefits of education programs for older drivers or drivers with dementia are unproven.

In-Person License Renewal or Restricted Licenses
In a Class 2 study of all-aged drivers (Mayhall, 2002), the application of driving and licensing restrictions to at-risk drivers resulted in a reduced crash rate of 12.8 percent (2.4 to 23.2%) and a reduced violation rate of 10 percent (4.4 to 15.7%). In drivers over age 70, two Class 2 studies have reported conflicting results: one (Levy, 1995) reported a slightly lower risk of a fatal crash in States with mandated visual acuity[5] tests (RR 0.93; 0.89 to 0.97); the second study (Grabowski, 2004) reported no difference except for mandated in-person license renewal for drivers over 85 (fatal crash RR 0.83, 0.72 to 0.96).

Comment: None.

Summary:

Because age and medical diagnosis alone are often unreliable criteria for licensure, decisions on fitness to drive should be based on empirical observations of performance. There is variability in the psychometric support for various driving tests, and debate remains regarding the "Gold Standard" for driving ability. State road tests provide qualitative assessments of driving behavior, and are often considered the determinant of driver competence. However they are typically designed to test if novice drivers know and can apply the rules of the road, not to predict crash involvement in skilled drivers who may now be impaired. They are rarely able to evaluate driving competence in unsafe or emergency conditions.

State-recorded at-fault crash data are a reasonable surrogate measurement of unsafe driving. However, crashes are sporadic, uncontrolled events during which few objectives observations can be made. Personal accounts and State crash records may be incomplete, and crashes are under-reported. Crash data are somewhat insensitive, because not all certifiably unsafe drivers have had a crash and nonspecific because not all drivers with an at-fault crash are unsafe drivers. Crash data that do not include an at fault determination are even less sensitive and specific. Self-reported at-fault crashes are underreported relative to caregiver-reported crashes and State-recorded crashes. Driving simulator studies permit qualitative and quantitative assessments and can evaluate driving behavior in (simulated) dangerous circumstances, but have varying degrees of standardization and "ecological validity."

Current evidence shows several potentially useful clinical associations between a specific cognitive test and driving outcome, although cut-points for safe-unsafe driving often vary between studies or are not provided. In the absence of clear cutoffs, cognitive test scores in the range of moderate dementia[7] may be construed to raise the same level of concern as a CDR[133] of 1 (moderate dementia).

Tests of attention, executive functioning, visuospatial[134] skills, and memory are useful to assist in assessments of drivers with Alzheimer's disease[12]. There is sufficient evidence to recommend the use of Trails B[26] , UFOV[233], Line Orientation[135], Block Design[137], BVRT-

Copy[139] and BVRT-Recall, CFT-Copy[141], Facial Recognition[142], and Logical Memory in assessments of drivers with Alzheimer's disease. For patients with Parkinson's disease[58], there is sufficient evidence to recommend tests of executive functioning, and visuospatial skills for use in driving assessments. There was also evidence to recommend the use of Trails B. Potential sources of error and bias in these studies must be considered. Many studies report univariate analyses.

As many cognitive tests are inter-correlated, it is unclear in these reports whether significant findings represent unique strengths of a specific test, or if other inter-correlated tests better predict a driving outcome. Similarly, when studies included control subjects, most did not adjust analyses for diagnosis. In these studies, it is not possible to determine predictive value ("added value") of tests beyond diagnosis. The very diagnosis of dementia[7] depends on cognitive tests.

Another issue is whether to use raw or transformed (scaled) neuropsychological[75] test scores in predictions of driver safety. Neuropsychological test scores are often corrected (e.g., scaled for age, education or gender) to improve ability to detect deviations from normative reference groups. Yet, it can be argued that what matters on the road is pure ability, regardless of demographic characteristics. For instance, if a driver exhibits slowed processing speed, it matters that they are slow compared to all other drivers, not just compared to other drivers in the same demographic group. Consequently, efforts to relate neuropsychological performance with driving performance and to generate predictions of safety in individual older drivers at risk for dementia should consider using raw scores. Evidence suggests that individuals over 70 years are at critical risk for developing age-related cognitive deficits. Raw neuropsychological test scores across this group of older drivers will have largely the same meaning for driving, and the number who screen positive for unsafe driving will tend to increase with age. For instance, a raw score of 212 for Trails B[26] will screen positive (unsafe) in 5 percent of 70-year-olds and in 16 percent of all 81-year-olds.

Different clinical approaches and judgments are needed for younger patients in whom test scores have different implications: a 55-year-old who performs like an average 80-year-old on neuropsychological tests may well have significant brain disease.

Chapter 4: Medical Conditions

Diabetes

In diabetes[15] the body does not produce enough insulin[29] or properly use it, resulting in elevated blood glucose[163]. Genetics, obesity, and inactivity are factors. Over 20 million children and adults in the United States are estimated to have the disease. Many individuals with diabetes are unaware that they have it. Most people with diabetes are adults who have type 2 diabetes[164] due to insulin deficiency and resistance. A minority (<10 percent) have type 1 diabetes[165] due to failure of the pancreas to produce insulin. In pre-diabetes[166], blood glucose levels are higher than normal but not high enough to diagnose diabetes. Other causes of high blood glucose include gestational diabetes[167], steroid medications, and pancreatitis[168].

Treatments for diabetes include oral hypoglycemic agents[169] and injected insulin. Oral hypoglycemic drugs slow down absorption of sugars from the gut, decrease glucose release from the liver, increase glucose uptake by fat and muscle cells, or have a combination of actions such as appetite reduction, increased production of insulin, and decreased glucose release from the liver. Standard human insulin begins to act within 30 to 60 minutes of injection, achieves peak effect in 2 to 3 hours, and acts for 6 to 8 hours when injected into the abdomen at a dosage of 0.1 to 0.2 U/kg. Duration of action is prolonged when a larger dose of regular insulin is injected into the thigh or hip. Short-acting insulin has more abrupt effects on blood glucose levels.

Diabetes can result in high blood sugar producing frequent urination (polyuria[170]), extreme thirst (polydipsia[171]), weight loss, fatigue, irritability, and blurred vision. Treatment of diabetes with diet, oral hypoglycemic agents, and particularly insulin to reduce blood sugar may result in acute hypoglycemia[14], with confusion, coma, and even death. Chronic complications of diabetes include heart and blood vessel disease, stroke (large and small blood vessel), visual loss due to retinopathy[98] and hemorrhages[172], foot ulcers, infections, neuropathy[173], joint deformities (Charcot joints), pain, and kidney disease or failure (and effects of dialysis). (For more information on diabetic retinopathy see page 53). Some patients require kidney transplants and take immune therapy. People with diabetes tend to have risk factors for heart disease including obesity, high blood pressure, and atherosclerosis[174]. Drugs that lower blood pressure and cardiac drugs may affect people due to fluid and electrolyte shifts, low blood pressure, and psychoactive effects. Medications for neuropathy can affect brain function. These secondary factors complicate predictions of driver safety in diabetes.

According to the National Institution of Health, diabetic neuropathy is a peripheral nerve disorder caused by diabetes or poor blood sugar control. It can develop slowly after many years of diabetes or may occur early in the disease. People with diabetes may develop nerve damage throughout the body and may manifest symptoms that include pain or numbness in the hands, arms, feet, and legs. The most common types of diabetic neuropathy may results in problems with sensation in the feet.

The pain can be intense and require treatment to relieve the discomfort. The loss of sensation in the feet may also increase the possibility that foot injuries will go unnoticed and develop into ulcers or lesions that become infected. In some cases, diabetic neuropathy can be

associated with difficulty walking and some weakness in the foot muscles. There are other types of diabetic-related neuropathies that affect specific parts of the body. For example, diabetic amyotrophy causes pain, weakness, and wasting of the thigh muscles, or cranial nerve infarcts that may result in double vision, a drooping eyelid, or dizziness and lightheadedness.

Most people with diabetes will eventually have some kind of neuropathy. Symptoms may develop at any time; however the longer one has diabetes[15] the greater risk of symptoms. These symptoms may affect the person's ability to operate a motor vehicle safely due to the diminished sensation of the hands and feet while operating the steering wheel and pedals of the vehicle. In addition, the long-term effects on vision and cognition may place the safe operation of a vehicle at increased risk.

Review of Evidence on Driver Safety and Performance With Respect to Diabetes:

Driver Safety: The best available evidence on diabetes and driving is of low-to-moderate methodologic quality. This evidence indicates that the average driver with diabetes (type 1[165] or type 2[164]) has a statistically significant (19%) increase in risk for a motor vehicle collision compared to individuals without diabetes. One possible mechanism for crashes is hypoglycemia[14]. While some case reports support this, no well-designed study has provided direct evidence. Indirect evidence from multiple independent studies consistently shows that moderate-to-severe hypoglycemia impairs driving ability, cognition, and psychomotor function in some individuals with type 1 diabetes. A body of evidence indicates that insulin[29] therapy is a key risk factor for hypoglycemia, yet evidence is not yet clear on whether insulin-dependent drivers are at a greater risk for a motor vehicle collision than non-insulin-treated drivers. Individuals with insulin-treated diabetes may self-restrict and have less exposure to risk. Because indirect evidence suggests that hypoglycemia is a key factor to increased crash risk in diabetes, educational programs have aimed to diminish its incidence. Blood glucose awareness training[175] (BGAT[176]) appears to improve the ability to estimate blood glucose levels in type 1 diabetes, but it is not clear if this leads to measurable reductions in episodes of severe hypoglycemia. The value of BGAT has not been assessed in type 2 diabetes. More studies are needed that directly compare crash risk data of individuals with non-insulin- and insulin-dependent diabetes and matched individuals without diabetes.

Driver Performance: Drivers with diabetes, as a group, are at an increased risk of having crashes. Although it is agreed that the major risk involved is that associated with hypoglycemia, it appears that the hypoglycemic phenomenon by itself does not explain all the increased risk. Consequently, all drivers with diabetes should be counseled to the effect that they are at increased risk and that even mild hypoglycemia should be avoided when they are driving. Frequent stops and snacks, easy availability of glucose supplements, and early recognition of signs of impending hypoglycemia are important in this context.

DMVs[4] concentrate their efforts on those drivers who suffer hypoglycemic[14] episodes that require the assistance of a third party. Any drivers who experiences such episodes must not drive until their treating clinicians are certain that the risk of a repetition has been minimised. In some instances this period without driving may last several months and some experts feel that a three-month period for almost everyone in this situation would be appropriate.

However, it is really the clinical judgment of the treating clinician that is the important factor since the individual's particular situation will be the major factor.

Recurrent hypoglycemic episodes that require third-party intervention are a counter-indication to driving. Resuming driving for such an individual will, once again, depend upon an informed opinion from the treating clinician.

Hypoglycemic unawareness, where the hypoglycemic episode occurs with no forewarning being perceived by the individual, is an absolute counter-indication to driving. As long as the unawareness persists, the person must be disqualified from driving.

Insulin[29]-treated diabetes[15] is not, in itself, a justification for disqualification. However, the potential for a hypoglycemic episode is considered to be higher for the individual with insulin-treated diabetes than for a person treated by oral medication. Consequently, patient education as to the problems associated with driving and insulin-treated diabetes is important for this group.

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:

A person with a clinical diagnosis or history of diabetes mellitus who seeks a license to drive a motor vehicle should be examined and certified by a qualified clinician (M.D./D.O.[177]) periodically. Those who encounter difficulties with control should be seen more frequently in accordance with their treating clinician's assessment of their requirements for follow-up and control. Any changes in status — for example, the initiation of insulin treatment — should be communicated to the DMV, preferably by the driver himself.

Recurrent hypoglycemic episodes requiring third-party assistance are incompatible with safe driving unless certification by the treating clinician demonstrates that the driver has been stable for three months. Following a hypoglycemic episode requiring third-party assistance, a driver should not resume driving unless the treating clinician has certified that the diabetes is under control. Hypoglycemic unawareness is incompatible with driving. Drivers with diabetes who experience hypoglycemic episodes requiring the intervention of a third-party should be subject to periodic medical controls at a frequency to be determined by the DMV.

Before recommending that a patient with diabetes continue driving, the treating clinician should ensure that there is a good understanding of the disease, that the patient is free of hypoglycemic episodes, and that the patient is willing to follow the suggested treatment plan. The patient's compliance with the suggested therapy and the maintenance of blood sugar readings within an acceptable range are important in establishing the patient's understanding and management of their condition. The patient should demonstrate that they are able to recognize incipient hypoglycemia[14] and can take the appropriate action when they become symptomatic.

To be certified to drive the applicant should be judged to be compliant with diabetes[15] therapy and unlikely to have reduced driving ability due to diabetes or to complications affecting other organ systems (e.g., vision, cardiovascular, neurological[32]) mediating abilities that are critical to safely operating a motor vehicle.

Before issuing a license, DMVs should require individuals with diabetes who require antihyperglycemic therapy[178] to be free of a pattern of repeated episodes of severe hypoglycemia (i.e., insulin[29] reactions) of 45 mg/dl or less, not have hypoglycemia unawareness, and show they are willing and able to properly monitor and manage their diabetes.

DMVs should require drivers who use insulin to agree and comply with the following: (a) develop and maintain a clear and demonstrable understanding of the relationship between blood sugar levels, food intake, exercise, insulin intake, and temporal effects of different insulins and doses, by means of diabetes training, and (b) submit a copy of the clinician's report to the DMV at the time of the recertification.

Driving with diabetes treated with oral drugs or insulin can be a challenge. Individuals with diabetes must plan their trips taking into considerations the particularities of their medical condition. Frequent stops, blood sugar checks every four hours, regular meals or snacks, and good hydration are essential for long trips. Drivers should interrupt their trips if they feel symptoms of impending hypoglycemia or if their blood sugar is lower than 70 mg/dL. They should not resume driving until they have recuperated completely. Drivers with diabetes treated with oral drugs or insulin should wear bracelets identifying them as having diabetes.

Any driver who suffers a hypoglycemic episode necessitating the assistance of another person must cease driving immediately and not resume driving until their treating clinician has informed them that they may do so. All drivers with diabetes should see their treating clinician on a regular basis. The frequency of visits will be determined by the clinician according to their assessment of the clinical situation.

Evidence:

1. Individuals With Diabetes[15] Mellitus Are at a Greater Risk for Motor Vehicle Crashes Compared to Individuals Without Diabetes

Thirteen low-to-moderate quality case-control studies compared crash risk among drivers with diabetes to drivers without diabetes. A fixed-effects meta-analysis of pooled data showed that the risk for crashes among drivers with diabetes was 1.19 (95% CI: 1.08–1.31) times greater than the risk for crashes among comparable drivers without diabetes (Tregear et al., 2007). The strong findings are weakened by factors related to study design, procedures, and potential bias inherent in case-control studies, particularly failure to control for differences in exposure to risk (amount of driving) between groups. Yet data from the 13 studies was homogeneous, suggesting that failure to control for differences in exposure did not result in biased risk-ratio estimates. Also, a sensitivity analysis that compared risk-ratio data in studies that controlled for exposure and studies that did not, found no evidence that

failure to control for exposure produced a systematic over or underestimate of the observed risk ratio.

It is unclear if drivers with type 1[165] or type 2 diabetes[164] are overrepresented among drivers who have had motor vehicle crashes.
Three moderate-quality case-control studies of individuals over 65 with type 2 diabetes compared the prevalence of drivers with and without diabetes among drivers who had and who had not had a motor vehicle crash. A random-effects meta-analysis showed that drivers with diabetes are overrepresented among drivers who have crashed, but the result did not reach statistical significance (Odds Ratio=1.41; 95% CI: 0.86–2.29, P=0.1760). Consequently, it remains unclear whether drivers with Type 2 diabetes are overrepresented among populations of drivers who have had motor vehicle crashes. There is no comparable evidence for type 1 diabetes.

It is unclear whether drivers with diabetes who use insulin[29] are overrepresented among drivers who have had motor vehicle crashes.
Three of the case-control studies above addressed this issue. This data was homogeneous and was pooled using fixed-effects meta-analysis. Drivers with insulin-dependent diabetes tended to be overrepresented among drivers who have had crashes, but this result did not reach statistical significance (Odds Ratio=1.35; 95% CI: 0.86–1.70, P=0.1695). More data are needed for an evidence-based conclusion on whether drivers with diabetes treated with insulin are overrepresented among drivers who have crashed.

Hypoglycemia[14] is a risk factor for a motor vehicle crash among individuals with diabetes mellitus.
Three small, moderate-quality studies assessed the effects of induced hypoglycemia on simulated driving ability in type 1 diabetes[165]. All three studies found that driving ability was impaired during hypoglycemia. However, there was little agreement on exactly which aspects of driving are vulnerable to hypoglycemia and at what hypoglycemia levels. The available studies examined effects of hypoglycemia in type 1 diabetes only. Due to a paucity of data, it is not possible to quantify the relationship between the deterioration in driving performance and blood glucose[163] levels.

2. Hypoglycemia[14] Impairs Cognitive and Psychomotor Function of Individuals With Type 1 Diabetes[165] (Insulin[29]-Dependent Diabetes[15] Mellitus)
A number of small, low-to-moderate-quality studies assessed the effects of induced hypoglycemia on cognitive and psychomotor function. These studies consistently showed that moderate hypoglycemia (blood glucose[163] levels of ~ 2.5-3.0 mmol/L [45–54 mg/dl]) produced acute decline on performance on a range of cognitive and psychomotor tasks in some (but not all) individuals with insulin-dependent diabetes. No comparable data are available on individuals with diabetes who do not need insulin.

3. Several Treatment Risk Factors Are Associated With an Increased Risk of Severe Hypoglycemia in Diabetes Mellitus.
Known treatment-related risk factors for severe hypoglycemia include lower HbA1c, insulin use, and multiple insulin injections per day. Whether specific treatments (types of insulin, oral hypoglycemic drugs, or combinations thereof) increase the incidence of severe

hypoglycemia in diabetes remains unclear. Epidemiology provides study designs for evaluating risk factors associated with a particular condition among representative populations, while controlling for other known risk factors. Several case-control studies or cohort studies attempted to determine the relative risk for hypoglycemia with differing treatment options, regimes, or modes. Most available information comes from efficacy and safety studies, usually randomized controlled trials[161] (RCTs)[162], which may be considered to be the "gold standard cohort studies" for assessing treatment efficacy and safety. However, RCTs may not accurately estimate the true incidence of hypoglycemia because they tend to be small and short-term, enroll selected patients who do not reflect the broader population, and use protocols that do not reflect real-world disease management.

4. <u>Whether Hypoglycemia Awareness Training Can Prevent Consequences of Hypoglycemia Is Unclear</u>

Blood glucose awareness training[175] improves the ability of individuals with type 1 diabetes[165] to accurately estimate their blood glucose[163] levels. Five low- to-moderate-quality studies demonstrated that BGAT improves the ability of individuals with type 1 diabetes to accurately estimate their blood glucose levels. However, it is not clear if BGAT reduces the occurrence of severe hypoglycemia. Two moderate-quality studies examined the incidence of severe hypoglycemia following BGAT in individuals with type 1 diabetes. One study found a benefit and the other did not.

Chapter 4: Medical Conditions

Obstructive Sleep Apnea

Driver sleepiness is a major cause of motor vehicle crashes. Most of these crashes probably occur in otherwise healthy but sleep-deprived drivers, but drivers with obstructive sleep apnea[18] (OSA[19]) appear to be at particular risk. Other causes of excessive driver sleepiness include sleep deprivation due to medical, neurological[32], and psychiatric disorders, chronic pain, licit and illicit drug usage, narcolepsy[22], idiopathic hypersomnia[179], restless leg syndrome[180], and shift work sleep disorder.

OSA is caused by recurrent airway obstruction during sleep. Obstruction causes apnea[181], the cessation of breathing, which reduces blood oxygen saturation. The tongue, tonsils, and other tissues can obstruct the upper airway, especially when muscles relax and the airway collapses during sleep. Jaw and airway structure and nasal pathway obstruction may also be factors in OSA. Treatments for OSA include continuous positive airway pressure[35] (CPAP[36]), surgical procedures, medications, and treatment of underlying risk factors, particularly obesity.

Some individuals with OSA may be unaware of their sleepiness and cognitive impairment, leading them to unwittingly engage in risky driving behavior. OSA is relatively common and affects about 2 to 4 percent of middle-aged people, many of whom have not been diagnosed. Sleep fragmentation leads to chronic sleep deprivation and excessive daytime sleepiness[182] (EDS[183]), a cause of cognitive dysfunction. Repeated nocturnal hypoxia[184] also causes cognitive deficits, some of which may be irreversible. Symptoms of OSA include chronic loud snoring, witnessed apneas or breathing pauses during sleep, and daytime sleepiness.

Review of Evidence on Driver Safety and Performance With Respect to Obstructive Sleep Apnea:

Driver Safety: OSA increases crash risk. The predictors of a crash are self-report of sleepiness (which is not particularly reliable); body mass index[185] (BMI[186]), and apnea hypopnea index[20] (AHI[21]). The gold standard for assessing OSA is to conduct a polysomnograph[187] (PSG[188]) or an overnight sleep study in a laboratory, although portable monitoring devices have also been used. CPAP is the only treatment demonstrated to reduce crash risk. However, once initiated, the treatment must be continued for as long as the person wishes to maintain their driver's license. It is difficult to show reduction of crash risk after one night of CPAP, but there is measurable improvement in surrogate markers of crash risk (e.g., disordered breathing, blood oxygen saturation). CPAP reaches optimal effectiveness after two weeks. Any interruptions of CPAP, even if it's only for one day, can have adverse effects on driving fitness. Since CPAP takes at least two weeks to be fully effective, any interruption in treatment means at least a two-week interruption in driving. In the event of non-compliance for a patient with OSA, no matter what the reason, driving should be ceased immediately.

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:

1. Drivers with daytime drowsiness should not drive until the therapy suggested by the treating clinician has been shown to be effective. Even then, such drivers should monitor their drowsiness and cease driving immediately if they feel drowsy. A diagnosis of OSA[19] precludes unconditional certification to drive a motor vehicle. A person with OSA may drive if they have untreated OSA with an AHI[21] of 20 or below (an issue to resolve) and no daytime sleepiness, or has OSA that is being effectively treated. An individual with OSA who meets these requirements should be recertified annually, based on demonstrating satisfactory compliance with therapy. Drivers with daytime sleepiness of an AHI of 20 or more may drive only if the condition has been treated effectively for as long as the patient continues the therapy. Ceasing the therapy should be accompanied by driving cessation if the OSA is still present.

2. People with a clinical diagnosis or history of OSA who seek certification to drive a motor vehicle should be examined and certified by a qualified clinician at least annually. The clinician who would be evaluating and treating drivers should be a qualified clinician (M.D./D.O.[177]) with relevant expertise in sleep apnea[181]. To be certified to drive the applicant should demonstrate compliance with OSA therapy (see introduction) and unlikely to have reduced driving ability due to OSA or to complications affecting other organ systems (e.g., vision, cardiovascular, neurological[32]). Also, individuals with OSA who require CPAP[36] therapy should be free of repeated episodes of sleepiness, not have unawareness of impairment, show they are willing and able to properly monitor and manage their OSA, and sign a document indicating adherence to OSA therapy and awareness of risk of sleepy driving.

3. Drivers with OSA should not be certified for unrestricted driving if they report excessive sleepiness while driving, or have had a crash associated with falling asleep, or have an AHI > 20 and have not yet been treated for OSA successfully, including demonstration of adherence to therapy, or have been noncompliant with treatment. Drivers treated with surgery need to be re-evaluated for driving safety.

4. Driver's license applicants who meet the following criteria should be evaluated for OSA: high risk for OSA according to the Berlin Questionnaire[189], BMI[186] $\geq$ 33 kg/m2, small jaw, large neck size ($\geq$ 17 inches in a man or $\geq$ 15.5 inches in a woman), small airway or at risk for OSA based on a clinical evaluation. DMVs[4] may screen for OSA in drivers.

5. Individuals with OSA who have had surgery treatment for weight loss may be certified to drive if they are compliant with CPAP, or are 6 months post-surgery (providing time for weight loss), have an AHI $\leq$ 20, are no longer excessively sleepy, and are cleared by the treating clinician. Individuals off CPAP therapy should be instructed to seek reevaluation if they gain significant weight or symptoms of OSA recur.

6. Individuals with OSA[19] who have been treated for apnea[181] with oropharyngeal[190], tracheostomy[191], or facial bone surgery may be certified if they are more than 1 month post-surgery, are cleared by treating clinician, have an AHI[21] ≤ 20 and are no longer excessively sleepy. Individuals off CPAP[36] therapy should be instructed to seek reevaluation if symptoms of OSA recur.

7. Drivers with OSA who use CPAP must agree and comply with:
   (a) submitting sleep logs and CPAP usage to their clinician at their periodic examinations or when directed by their State DMVs,
   (b) submitting a copy of the clinician's report to the DMV at the time the recertification, and
   (c) undergoing education on the importance of adequate sleep and relevant lifestyle changes including weight loss, smoking cessation, regular exercise, reduced alcohol consumption, treatment compliance, consequences of untreated OSA including loss of driver's license, motor vehicle collisions, hypertension[192], cognitive dysfunction[193], heart disease[194], reflux esphagitis[195], headaches, sleep disruption, reduced quality of life, shorter survival, and effects of respiratory or central nervous system depressants on OSA.

Evidence:

1. <u>Drivers With OSA Have a Greater Motor Vehicle Crash Risk Than Individuals Without OSA</u>

Seventeen case-control studies of low to moderate quality show that drivers with OSA are at greater risk for motor vehicle crashes than similar drivers without OSA. Analysis of combined data from 9 of the 15 studies showed that individuals with OSA are between 30 percent and 472 percent more likely to have a crash. The mean crash risk ratio is 2.72, which indicates individuals with OSA have a 172 percent increased chance of a motor vehicle crash (Tregear et al., 2008)

2. <u>Several Disease-Related Factors Predict Increased Motor Vehicle Crash Risk in OSA</u>

Ten studies addressed these issues in OSA. Several parameters repeatedly indicate high motor vehicle crash risk: (a) Severity of disordered respiration during sleep indexed by the AHI[21] or the RDI[196]; (b) presence and degree of daytime sleepiness measured using the ESS[197] (Epworth Sleepiness Scale[198]) but not MSLT[199] (Multiple Sleep Latency Test[200]) or MWT[201] (Multiple Wakefulness Test[202]); (c) blood oxygen saturation level; and (d) BMI[186]. There are no clear cut-points for the prediction measures. Evidence suggests a continuum, e.g., as BMI increases motor vehicle crash risk increases. Research shows a difference in crash risk between obese (defined as BMI of 30 or greater) and non-obese individuals.

3. <u>Individuals With OSA</u>[19] <u>Become Unsafe Soon After Cessation of CPAP</u>[36] <u>(e.g., Due to Noncompliance)</u>

Evidence suggests that individuals with OSA are not good at judging how sleepy they are. Three studies used ESS[197] self-report questionnaire scores to index sleepiness before and after treatment with CPAP. In one study, subjects with moderate-to-severe OSA judged their sleepiness levels before CPAP as being much higher than they had originally reported.

Another study found discrepancies between subjective and objective measures of sleepiness on ESS and MSLT[199] scores. A third study found no difference in ESS in OSA and ESS scores estimated by their partners.

4. Screening and Diagnostic Tests May Help to Identify Individuals With OSA (Who Are at Increased Risk for Crashes)

Severity of OSA is most accurately measured with PSG[188] in controlled clinical settings. Forty-three studies (32 high-quality, 11 moderate-quality) assessed if different portable treatment systems are as good as a PSG test in a sleep lab for assessing OSA. The portable instruments are not as accurate, but may be a sufficient and less expensive alternative to a PSG test in a sleep lab. Cost-benefits analysis would be needed to determine consequences of false negative and false positive outcomes with a portable system. No psychometric instrument, score, or model has been shown to accurately predict motor vehicle crash risk in individuals with OSA. (See Centers for Medicare & Medicaid Services 2008 guidelines regarding use of portable units.)

5. OSA Treatment Can Reduce Crash Risk

Several randomized control trials assessed treatments for OSA. Only CPAP is shown to reduce crash risk in OSAA meta-analysis. Tregear et al. (2008) indicated that crash risk declines by ~ 72 percent following CPAP. It is not clear if CPAP reduces crash risk in OSA to normal levels. Some patients may not recover fully because of co-morbid factors such as cerebral vascular disease or effects of repeated hypoxia[184] on brain function. Other interventions in OSA include medications, dental appliances (mandibular advancement), surgery (uvulopalatopharyngoplasty[203]), behavioral modification, and weight loss, but there is insufficient evidence on how these affect driving or surrogate measures.

6. Optimal Treatment of Sleep Disordered Breathing in At-Risk Drivers With OSA Is Reached Within 2 Weeks

Twenty-four studies assessed time to reach optimal effectiveness of therapy in OSA. These included 8 high-quality, 14 moderate-quality and 2 low-quality studies. Crash risk reduction among individuals with OSA is reported after as little as one night of CPAP. Simulated driving performance, severity of disordered respiration, blood oxygen saturation, and some cognitive and psychomotor performance scores also improve after one night of CPAP. The number of nights needed to reach maximum CPAP benefit is probably <2 weeks.

7. Individuals With OSA[19] Become Unsafe Soon After Cessation of CPAP[36] (e.g., Due to Noncompliance)

Four studies assessed the effects of stopping CPAP. CPAP cessation increases OSA severity and daytime sleepiness and decreases simulated driving performance. Deterioration may occur as soon as 24 hours after CPAP cessation.

Chapter 4: Medical Conditions

Seizures

A seizure[17] is a sudden alteration in behavior that may range from loss of consciousness or body control to a mild subjective feeling, due to acute abnormal brain electrical activity. People who have had a seizure are generally at greater risk for another seizure than people who have never had a seizure. The risk depends on the underlying cause. As a rule, the longer the seizure-free period, the less likely a person is to have another seizure. Epilepsy[16] is the common medical disorder characterized by recurrent seizures. Patients with epilepsy (seizure disorders) are at increased risk for motor vehicle crashes because of a seizure, the underlying condition causing seizures, or anti-epileptic drug[30] (AED[31]) side effects. Epilepsy patients who have ongoing seizures are legally or medically forbidden to drive. Many patents with epilepsy (perhaps two-thirds) have well-controlled seizures based on effective treatment with AEDs or (less commonly) surgery for epilepsy. Patients who are seizure-free for periods varying from 3 to 18 months are generally permitted to seek driving privileges, and many drive.

The incidence of epilepsy is approximately 0.5-1.0 percent worldwide, in the range of type 2 diabetes[164], lung cancer in men, or breast cancer in women. In the United States there is a 9- to 10-percent lifetime risk of a spontaneous seizure. In epilepsy, the risk of another seizure drops below 2 percent in patients who are seizure-free for more than 10 years, an annual risk of approximately .05 percent. However, it is not possible to predict precisely whether and when a subsequent seizure will occur.

The many causes of seizures include stroke[23], tumor, trauma, hypertension[192], infections, abnormal blood vessels of the brain, complications of pregnancy, liver and kidney disease, alcohol, illicit drugs such as cocaine, medication withdrawal, and high fever in children. Epilepsy includes a range of seizure types, some of which pose greater risks for driving safety than others. Some types of epilepsy (such as febrile seizures[204]) are confined to childhood and resolve in adulthood; other types may occur only at night while asleep.

Broadly, seizure types may be considered as either partial or generalized. Partial seizure[205] types are most common, occurring in approximately 70 percent of all those with seizures, and are either simple partial[206], complex partial[207], or secondary generalized[208]. Symptoms of partial seizures depend on which area of the brain generates the seizures and how quickly and how far an individual seizure may spread through the brain, and commonly vary in type within a given individual. In simple partial seizures, the patient is alert, conscious, and remembers what happened during the event. Depending upon which area the seizure arose from in the brain, behavioral alterations vary between abnormal motor activity such as posturing or twitching, peculiar ideation including déjà vu (the feeling that something that should be unfamiliar has happened before), a feeling of numbness or tingling, or peculiar visual sensations such as flashing lights or even formed hallucinations[63]. In complex partial seizures[207], consciousness is impaired, and patients cannot recall what happened. A partial seizure of either of these types may also progress to a generalized seizure.

Generalized seizures[208] include several types. Tonic-clonic seizures[209] (grand mal seizures) generally last between 30 seconds to 2 minutes and start with body stiffening followed by

jerking of the arms and legs, loss of consciousness, occasional tongue biting and loss of bladder or bowel control, and post-ictal[210] confusion. Tonic seizures[211] last 5 to 20 seconds and involve flexion and extension of the trunk, neck, and limbs, and often occur at night. Absence seizures[212] are brief (3 to 20 seconds) staring episodes that impair cognition and awareness without warning or post-ictal confusion. Atypical absence seizures[213] last up to 30 seconds, and include staring, and occasional eye-blinking and lip-twitching. Myoclonic seizures[214] involve jerking of the muscles of the neck, trunk, shoulders, upper arms, and upper legs, while conscious. Atonic seizures[215] last up to a minute, and are comprised of sudden loss of body tone, with head nods, jaw drops, falls, and impaired consciousness.

Review of Evidence on Driver Safety and Performance With Respect to Seizures:

Driver Safety: The U.S. mortality rate report indicates that the number of fatal driver crashes related to seizures[17] is relatively small. During a 3-year period there were 80 to 97 fatal crashes annually involving drivers with seizure disorders, indicating that only a small fraction of total fatal driver crashes in the United States are related to seizure occurrence while driving. Some seizure types probably create lower risk for driving than others. These include simple partial seizures[206] that do not interfere with consciousness or motor control, seizures with consistent and prolonged auras[216], a pattern of pure nocturnal seizures, and seizures related to acute reversible illnesses or exposures (such as anesthetics) that are unlikely to be repeated while driving. Retrospective studies of epilepsy[16] patients who had motor vehicle collisions attributed to seizures suggest that complex partial seizures[207] (involving loss of consciousness) pose the most significant risk, particularly when not preceded by an aura.

However, evidence to guide determination of fair State driving laws is still generally lacking; for example, one recent study of crash rates in drivers with epilepsy preceding and following a change in legal restrictions in Arizona (i.e., reduction from State requirements from a 12-month to a 3-month seizure-free interval) showed no significant increase in seizure-related crashes.

Regulations on driving certification vary but often require a seizure-free period on or off medications of several months, 6 months being common. Changes to regulations should be supported by evidence, readily enforced, and implemented at DMV[4] and medical examiner offices, and transparent to the public.

Severe restrictions may discourage drivers from reporting seizures to their clinicians, lessening the chances that they will seek treatment and increasing their health- and driving safety risks. In this situation, clinicians may be discouraged from reporting drivers who have had a seizure, but there is potential liability for certifying potentially unsafe drivers. Duration of the seizure-free period helps to predict future risk for seizure recurrence. The odds of crashing are markedly reduced with long seizure-free intervals. Annual risk of seizure recurrence is < 2 percent after 8 years and < 1 percent after 10 years (which is still 20 times greater than the general population seizure risk of 0.05% per year).

The tolerable risk of a seizure[17] while driving depends on specific circumstances. The risk relationship between seizures and car crashes is continuous, but not in a linear fashion; the

difference between 3 and 6 months is very small and there is no clear cutoff. A driver who is seizure-free for 6 months is probably safer to certify than a driver who has been seizure-free for 3 months, however there is no evidence to say that the latter have more crashes. Rules for commercial drivers are traditionally much more stringent because of the high stakes of a crash by, say, a driver of a passenger bus or tractor-trailer. Information on seizure-free periods as an index of seizure control often depends on patient accounts, which may be inaccurate. Consequently, evaluation of driving risk in epilepsy[16] should consider additional factors besides seizure-free interval, including specific seizure types, causes and treatment factors.

There are few data on crash risk in specific epilepsy subtypes, yet some types may carry lower risk. These include simple partial seizures[206] that do not interfere with consciousness or motor control, seizures with consistent and prolonged auras[216], a pattern of pure nocturnal seizures, and seizures related to reversible acute illnesses. Having a seizure differs from having a crash. Many patients will crash if they have a seizure while driving, but some with auras may have sufficient warning to abort a trip or pull off the road. There are concerns about the effects of discontinuing or altering a driver's anti-epileptic drug[30] (AED[31]) drug regimen because of increased seizure risk and drug side effects. AEDs that produce the lowest risk of cognitive and psychomotor impairment should be encouraged and drugs with highest risk of impairment should be discouraged. There is insufficient evidence on whether restricted licensure in epilepsy is an effective countermeasure.

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:

1. A diagnosis or history of seizures should preclude unconditional certification to drive.

2. A driver with a history of epilepsy who has been granted conditional certification to drive must be recertified on a periodic basis.

3. Antiepileptic drugs are known to produce side effects in some patients that may affect driving. Normally patients who are affected by AEDs will complain to their clinicians, who should then counsel them on restricting their driving until the side effects have passed. Such patients should have their levels of the drug monitored regularly and should be counseled to cease driving if toxic effects occur.

4. To be conditionally certified to drive the applicant should be judged (a) unlikely to have a seizure[17] while driving, (b) unlikely be impaired by the condition causing the seizures or to have complications in other organ systems mediating abilities that are critical to safely operating a motor vehicle, (c) free of a pattern of repeated episodes of AED[31] side effects or noncompliance, (d) show willingness and ability to properly monitor and manage the condition, (e) be educated not to drive for long hours without rest, not to drive when fatigued or ill, and to avoid excessive alcohol use, and (f) sign a document indicating adherence to AED therapy, awareness of AED toxicity, and seizure reporting requirements.

5. Following a unique seizure, the patient should not drive while under investigation. Driving may be resumed if the neurological[32] and cardiac investigations have not revealed a cause or if a treatable cause has been identified and the therapy successful. If the neurological investigation reveals that the patient is epileptic[16], they will be subjected to the local jurisdiction's medical standard for an epileptic seizure.

6. Following a diagnosis of epilepsy, the driver should undergo an annual examination by the treating clinician. The frequency of the controls by the treating clinician may be relaxed gradually in accordance with the treating clinician's clinical assessment of the situation.

7. Drivers with epilepsy must agree and comply with the following:

(a) know the regulations and restrictions for driving with epilepsy
(b) submit seizure logs to their clinicians at their periodic examination or when directed by their State DMV, and
(c) submit a copy of the clinician's report to the DMV at the time of the recertification.

8. Drivers with epilepsy who are seizure-free but still require AEDs for seizure control require periodic recertification on a case-by-case basis with medical reporting from private clinician.

9. Cessation of AEDs may lead to a new seizure. The driver who suffers a seizure following a prescribed cessation of AEDs should not drive until therapeutic levels of AEDs are achieved that are comparable to the levels prior to the cessation of AEDs.

10. People with alcohol withdrawal seizures should not be recertified unless a qualified clinician determines that they will abstain permanently from all further drinking. To qualify for recertification, the patient should have attended an alcohol treatment program and be seizure-free for at least 6 months. If substance abuse or dependence is present that meets the diagnostic criteria described in DSM-IV, driving is counter indicated until the person meets the diagnostic criteria for prolonged remission. Jurisdictional requirements vary for alcohol treatment program attendance and other measures such as ignition interlock devices that may be compulsory.

11. Drivers who take AEDs for seizure prophylaxis[217] or control should have their AED levels monitored (including serum drug levels as appropriate) and should be evaluated for signs of drug toxicity. They should sign an affidavit certifying they have been seizure-free for at least 6 months, compliant with medication, and free of drug side effects.

12. Drivers with epilepsy[16] who no longer require AEDs[31] and have not had a seizure[17] for at least 2 years should no longer require annual medical recertification.

13. Drivers with epilepsy who take AEDs should be warned not to drive after medication adjustment if the medication adjustment results in central nervous system adverse effects that could impact safe driving.

14. Drivers with epilepsy who take AEDs and experience central nervous system side effects that could impair driving safety in the opinion of the treating clinician should be warned not to drive until they are free from side effects following medication adjustments.

15. Drivers with epilepsy who take AEDs and have been seizure-free on AEDs, no matter how long, and then have their AEDs tapered should be warned not to drive after medication adjustment for a period of at least one to 3 months and should also have annual recertification for 2 years.

16. Patients who have had surgical treatment for epilepsy should be seizure-free for 6 months after surgery before seeking driver's license recertification, and should receive a neurological[32] examination to ensure that no major surgical complications resulting in cognitive or visual field impairment that could affect safe driving have occurred.

17. A history of a single, unprovoked seizure precludes unconditional certification to drive. A person who has a new seizure should not be eligible for licensure until a detailed neurologic evaluation is completed. Conditional certification to drive may be possible if the driver has been seizure-free for at least 6 months on or off AEDs. An individual who has had a single, unprovoked seizure and has been granted conditional certification to drive must be recertified after one year. Whether an individual who had had a single provoked seizure can be certified requires an expert medical evaluation to determine whether the individual is at low risk for exposure to the seizure precipitant. Examples include a lidocaine[218] induced seizure during a medical procedure, postconcussive[219] seizure in the immediate aftermath of a mild head injury, a seizure from an acute toxic metabolic[124] derangement not likely to recur, or an episode of convulsive syncope[220].

18. Individuals with a probable single episode of drug toxicity may be treated less restrictively than those with structural brain lesions, depending on the outcome of the neurological evaluation.

19. Individuals with seizures provoked by structural brain lesions (e.g., tumor, trauma, and infection) should be assessed more stringently than those with other causes (e.g., a single seizure caused by exposure to a drug, such as lidocaine, or a history of febrile seizures[204] in childhood).

20. Conditions that are at moderate-to-high risk for further seizures, which would militate against certification, include more severe head injury (with loss of consciousness or amnesia[221] greater than 30 minutes or penetrating head injury), brain hemorrhage[222] due to stroke or trauma, infections such as encephalitis[223], meningitis[224], brain abscess[225] and cysticercosis[226], stroke, tumors and brain surgery.

21. Individuals who have had an unprovoked seizure[17] and who have a history of a previous provoked seizure should be considered as having epilepsy[16].

22. A driver who suffers a convulsive seizure is unfit to drive for a period of at least six months following the incident. Resumption of driving requires a positive recommendation by the treating clinician.

23. A driver who suffers a convulsive seizure caused by abuse of alcohol or drugs is unfit to drive until they can demonstrate a period of at least six months of abstinence.

24. A driver with epilepsy is subject to periodic medical controls at a frequency to be determined by the DMV[4].

References:

Drazkowski, J. F., Fisher, R. S., Sirven, J. I., et al. (2003). Seizure-related motor vehicle crashes in Arizona before and after reducing the driving restriction from 12 to 3 months. Mayo Clin Proc; 78:819-25.

Gastaut, J., & Zifkiin, B. G. (1987). The risk of automobile accidents with seizures occurring while driving: relation to seizure type. Neurology; 37: 1613-6;

Hasegawa, S., Kumagai, K., & Kaji, S. (1991). Epilepsy and driving: a survey of automobile accidents attributed to seizure. Jpn J Psychiatry Neurol; 45: 327-31.

Evidence:

1. Individuals With Epilepsy Are at a Greater Risk for a Motor Vehicle Crash Compared With Individual's Without Epilepsy

A recent meta-analysis of available evidence indicates they are 1.13 to 2.16 times more likely to have a motor vehicle crash than comparable individuals who do not have epilepsy. The limited data come from several lower-quality studies. Additional data suggest a significant reduction in risk if a driver has a reliable aura[216] (seizure warning) before onset of a seizure.

2. Seizure Recurrence Likelihood Decreases as Time Since Last Seizure Increases in Patients Taking AED[31] Treatment.

The likelihood of seizures among those on AEDs is difficult to predict. No high-quality studies are available, but available data suggest that risk of seizure is significantly reduced after eight seizure-free years (to about 2% per year). The risk is further reduced to about 1 percent after 10 seizure-free years.

3. Seizure[17] Recurrence Likelihood Decreases as Time Since Last Seizure Increases in Patients Who Have Had Surgery for Epilepsy[16]

Limited data indicates that the longer a person is seizure-free, the less likelihood there is of a future seizure. The risk of seizures is similar to those of people on AEDs[31], about 2 percent per year after eight years.

4. Seizure Recurrence Risk After a Single Lifetime Unprovoked Seizure

There is a high rate of additional seizures in the second year; however seizure risk declines significantly so that the risk of seizure is about 2 percent by the fifth year.

5. Seizure Recurrence Risk and AED Therapy Compliance (Based on Serum Drug Levels)

One study showed no significant increase in crash rate regardless of whether a driver was consistent in taking AEDs. Four studies showed conflicting or inconsistent results. No evidence-based conclusion can be drawn.

6. Long-Term Effects of an AED on Surrogate Markers of Driver Safety Among Individuals With Epilepsy

Two small studies suggested a negative effect on driving skills, but the data were limited and neither relied on driving performance measures for results. No evidence-based conclusion can be drawn.

Chapter 5: Temporary Conditions

Introduction

DMVs[4] require a certain time to perform the administrative procedures involved in processing a dossier or case and rendering a decision on driver fitness. Consequently, conditions that will limit driving fitness for a short period of several weeks will be resolved before the DMV can complete the administrative procedures. Such temporary conditions are the purview of the treating clinician rather than the DMV and advice on fitness to drive should be included in the treating clinician's discharge instructions to his patient. Patients who refuse to follow the advice of the treating clinician should be referred to the DMV if the clinician believes that their driving is potentially hazardous, as recommended by the American Medical Association.

Anterior Cruciate Ligament Injury/Surgery

Surgical repair to the anterior cruciate ligament[227] in the right knee results in compromised stability of the joint and decreased reaction time in the weeks immediately following the operation.

Review of Evidence on Driver Safety and Performance With Respect to Anterior Cruciate Ligament Injury/Surgery:

Driver Safety: The literature review was unable to identify any study that examines the relationship between drivers with anterior cruciate ligament surgical repairs and safety, specifically motor vehicle collisions, injurious crashes, fatal crashes, or violations.

Driver Performance: Two studies examining partial task performance of driving (brake reaction time) were conducted using experimental designs to determine a safe time threshold to resume driving following surgical repair of the right anterior cruciate ligament. Gotlin and colleagues (2000) noted the brake response time decreased steadily over the 10 weeks following surgery, but clear improvements to the point of safety occurred until week 4. Nguyen, Hau, and Bartlett (2000) found that 75 percent of the sample returned to preoperative reaction time 6 weeks after surgery.

Table of the Quality of Evidence	
Measurement of Brake Response Time After Right Anterior Cruciate Ligament Reconstruction (Gotlin, Sherman, Sierra, Kelly, & Scott, 2000)	
Objective	Find out how many weeks is necessary to wait to drive after ACL[228] surgery.
Level/Design Participants	2 groups: 1 group (n=10) right ACL surgery; 1 (n=12) aged matched controls with no history of right knee dysfunction
Intervention and Outcome Measurement	Brake response time (BRT). How many weeks until they can drive again?
Results	Brake response time decreased over a 10-week period (P = .043). Clear improvement in BRT scores until week 4. Person with right ACL reconstruction can drive safely 4 weeks after surgery.
Limitations	Confounding variables may have delayed return to normal BRT if they had measured them. Limb strengthening typically does not occur until 3 to 6 weeks of rehab (can take place as early as 2). Study sample size was small and cannot guarantee they will be safe drivers at the point of 4 weeks.

Driving Reaction Time Before and After Anterior Cruciate Ligament[227] Reconstruction (Nguyen, Hau, & Bartlett, 2000)	
Objective	Determine driving reaction time of right knee in normal controls and in patients with ACL[228] instability in right knee or left knee.
Level/Design Participants	73 patients who underwent ACL reconstruction together with 25 normal subjects as controls. Driving reaction test performed on computer linked automobile simulator constructed by department of electrical and computer system engineering of Monash University.
Intervention and Outcome Measurement	Tests carried out 24 hours before operation and 2, 4, 6, and 8 weeks after surgery. Regardless of which knee was operated on, tests were performed on right leg. Performance of each of these 2 tests in 10 seconds was recorded.
Results	Six weeks post surgery, right ACL group: 37.5 percent returned to preoperative level in stepping test, 56.3 percent returned to standing test and 75 percent returned to reaction time test. Surgery on the left knee does not affect driving reaction time of right leg, and patients are able to resume as early as 2 weeks after surgery. After right ACL reconstruction patients should wait 6 weeks before resuming driving.
Limitations	Simulator only tested with automatic transmission.

Other Considerations:

Drivers enter surgery with varying levels of health and fitness with different comorbidities[229] of other diagnoses that may slow or hasten the healing process and therefore decisions about resumption of driving should consider the overall health and well-being of the driver. In addition, all studies were conducted with simulators using automatic transmission and therefore cannot make predictions about operating manual transmission vehicles.

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:
Individuals may resume driving 4 to 6 weeks following anterior cruciate ligament surgery.

Chapter 5: Temporary Conditions

Disk injury

Disk injuries typically involve a herniation[230] or rupture of one or more vertebral disks that provide cushioning and flexibility between each vertebra from the neck down to the pelvis. The status of a disk injury can range along a continuum and includes a bulge, herniation, rupture, surgical replacement, or removal and fusion of the vertebrae. The functional implications of a disk injury as they are associated to driving are largely due to pain, decreased range of motion, decreased strength, and impaired sensation. Individuals with disk injuries may have difficulty entering/exiting a vehicle, reaching/releasing the seat belt, fastening/unfastening the seat belt, operating the ignition, turning to see the entire driving environment to observe obstacles or make lane changes, maneuvering the leg between the accelerator and brake pedals, steering, or reaching for any vehicle controls located on the steering column or dashboard area.

Review of Evidence on Driver Safety and Performance With Respect to Disk injury:

Driver Safety: The literature review was unable to identify any study that examines the relationship between drivers sustaining a disk injury and safety, specifically motor vehicle collisions, injurious crashes, fatal crashes, or violations.

Driver Performance: A study of driving performance while wearing a neck orthosis[231], like a driver with a cervical neck injury would wear, revealed that the limited range of motion caused by the orthosis results in slower speeds, decreased lateral acceleration around corners, and less than optimal visual evaluation of traffic and obstacles at intersections (Barry, Smith, Lennarson, Jermeland, Darling, Steirman, et al., 2003). The authors suggest that while there is no evidence that wearing a neck brace increases crashes, there could be an increased risk for crashes.

Table of the Quality of Evidence	
The Effect of Wearing a Restrictive Neck Brace on Driver Performance (Barry, Smith, Lennarson, Jermeland, Darling, Stierman, et al., 2003)	
Objective	Assess the effects of wearing a restrictive neck brace on driver performance on the open road.
Level/Design Participants	Prospective, randomized block design[137], 23 licensed drivers without neck injuries.
Intervention and Outcome Measurement	Completion of a 20-minute road test both with and without a cervical orthosis[231].
Results	The cervical orthosis reduced cervical range of motion while driving and resulted in decreased speed, decreased lateral acceleration, and suboptimal evaluation of intersection traffic.
Limitations	Narrow sample size. Sample did not have neck problems and therefore the results may not accurately reflect driving performance in a person experiencing decreased mobility and pain.

Other Considerations:
Individuals with disk injuries may be taking prescription or over-the-counter medication to alleviate pain and therefore all medication contraindications[80] should be considered including drowsiness and medication interactions.

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 the complicated and variable nature of disk injuries related to location and severity, individuals with limitations in other areas of functional performance should be considered on a case-by-case basis with comprehensive testing to determine fitness to drive.

Chapter 5: Temporary Conditions

Fracture

Fractures, or a broken bone, can be sustained in any of the 206 bones of the body. When a bone in one of the extremities occurs, it may interrupt operation of the vehicle controls due to pain or limitations in range of motion from a cast or external fixator[232]. In these situations where there is an acute injury (fracture, dislocation) or a post-surgical situation, the functional limitations may be temporary. Individuals may have difficulty operating the foot pedals if the right lower extremity is fractured and may have difficulty with steering, shifting gears, operating the directional signal, turning the ignition, or any other control requiring reach or dexterity if a bone in the upper extremity is fractured. As long as the immobilization is in place or the affected articulation has not achieved full mobility the driver should be advised to refrain from driving. Attempting to drive using the unaffected left leg to operate the pedals, using a stick to work the clutch, or having a co-driver work the stick-shift are not safe alternatives to temporary driver cessation in this situation.

The removal of an immobilization after several weeks of immobilization does not imply instant fitness to resume driving. A three to four week immobilization of an ankle may take up to nine weeks before the ankle achieves full function. While this does not mean that the resumption of driving requires an additional nine weeks, it does mean that resumption should only occur when the mobility of the articulation is adequate for driving rather than immediately following cast removal.

Review of Evidence on Driver Safety and Performance With Respect to Fracture:

Driver Safety: The literature review was unable to identify any study that examines the relationship between drivers with fractures and safety, specifically motor vehicle collisions, injurious crashes, fatal crashes, or violations.

Driver Performance: In a study of control over vehicle functions comparing three different upper-extremity casts, it was determined that casts that restrict thumb movement significantly impair control (Blair, Chaudhri, & Gregori, 2001). A similar study comparing driving performance with short and long arm casts on the left and right extremities discovered the inability to drive safely with any type of cast on either upper extremity (Kalamaras, Rando, & Pitchford, 2006). The ability to return to driving after a lower-extremity fracture is considered differently as individuals need to quickly and accurately operate the vehicle foot pedals. A repeated measures study of 31 individuals following surgical repair of ankle fractures was conducted against a healthy control sample and determined that nine weeks following surgery drivers' reaction times returned to normal (Egol, Sheikhazadeh, Mogatederi, Barnett, & Koval, 2003).

Table of the Quality of Evidence

Doctor, Can I Drive With This Plaster? An Evidence Based Response (Blair, Chaudhri, & Gregori, 2002)	
Objective	Assess the effect of commonly used below elbow plaster casts on driving ability.
Level/Design	Case control study, same driver used for all tests after having three different casts

Participants	applied and completing separate driving tests.
Intervention and Outcome Measurement	Road test following the application of cast. Colles cast: below elbow cast leaving thumb and fingers free. Wrist flexed to 20°. Scaphoid casts: below elbow cast with thumb immobilized up to IP joint. Bennett's cast: below elbow cast with thumb immobilized in extension. Driving abilities tested: gear changing, steering, reversing, hand break control, indicator/horn control and around town driving.
Results	Colles cast is unlikely to affect driving controls in most cases. Scaphoid and Bennett's-type casts have significant effects on driving control.
Limitations	Only one person used to test three casts.

Lower Extremity Function for Driving an Automobile After Operative Treatment of Ankle Fracture (Egol, Sheikhazadeh, Mogatederi, Barnett, & Koval, 2003)	
Objective	Determine when patients recover the ability to operate the foot controls of a motor vehicle following operative repair of an ankle fracture.
Level/Design Participants	Repeated measures study of 31 individuals who had fractured their right ankles.
Intervention and Outcome Measurement	Measure of simulated driving performance on a simulator at 6, 9, and 12 weeks post-surgery. Each variable tested 6 times for each of 3 driving scenarios (city, suburban, and highway).
Results	Total brake time was 1,079 msec[72] for group I and group II- 1,330, 1,172, and 1,160 msec for group II at 6, 9, and 12 weeks. Total braking consistently improved for each of the driving scenarios at each successive data point. At 9 weeks, braking response returns to normal.
Limitations	Driving simulator was not actual vehicle.

Driving Plastered: Who Does It, Is It Safe, and What to Tell Patients (Kalamaras, Rando, & Pitchford, 2006)	
Objective	Determine the ability to safely drive while wearing an upper extremity cast.
Level/Design Participants	Case control study, same driver used for road tests wearing short and long arm casts on the right and left upper extremity.
Intervention and Outcome Measurement	A road test while wearing various upper-limb casts.
Results	**No cast:** Passed driving tests. **Right short arm cast:** Failed driving tests in both manual and automatic transmission vehicles. **Right long arm cast:** Failed driving tests in both manual and automatic transmission vehicles. **Left short arm cast:** Failed driving tests in both manual and automatic transmission vehicles. **Left long arm cast:** Failed driving tests in both manual and automatic transmission vehicles.
Limitations	Driving test carried out by professional rather than actual client so results may not accurately reflect how a driver with a painful fracture would perform.

Other Considerations:

A person who has sustained a facture may be using prescription or over-the-counter medication to alleviate pain and therefore all medication contraindications[80] should be considered, including drowsiness and medication interactions. In addition, factors other than reaction time should be considered prior to resuming driving, including pain and weight-bearing status.

Both studies of upper extremities were conducted in countries where driving occurs on the left side of the road and therefore results related to left versus right upper-extremity fractures should be interpreted with caution and consideration of the right-sided driving laws of the United States.

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:

Individuals with upper-extremity casts should delay driving resumption until the cast is removed if a large portion of the arm and/or the thumb is immobilized.

Chapter 5: Temporary Conditions

Hip Arthroplasty

A person undergoing hip arthroplasty[233] surgery has all or some of the parts of a hip joint replaced following a hip fracture or to replace a joint deteriorated from arthritis. Many surgical patients must adhere to strict "hip precautions" that prohibit certain movements of the hip for as long as three months. Those restricted movements -- hip flexion greater than 90 ° (often used to transition from accelerator to brake), hip internal rotation (often used to transition from accelerator to brake), and hip adduction (often used to transition from accelerator to brake) -- are typically involved in the operation of an automobile and transferring in and out of the vehicle. In addition, many individuals must adhere to weight-bearing precautions that limit the amount of force that can be pushed up through the hip that might become necessary during hard braking. The functional implications of hip arthroplasty are transferring in and out of the vehicle, operating the accelerator and the brake (with right hip surgery), and operating the clutch or emergency brake (with left hip surgery).

Review of Evidence on Driver Safety and Performance With Respect to Hip Arthroplasty:

Driver Safety: The literature review was unable to identify any study that examines the relationship between drivers with hip arthroplasty and safety, specifically motor vehicle collisions, injurious crashes, fatal crashes, or violations.

Driver Performance: Ganz and colleagues (2003) studied the rate at which reaction time returned following total hip arthroplasty surgery and found that reaction time returned four to six weeks following surgery. In an effort to speed the recovery process and return to function, Berger and colleagues (2004) studied a minimally invasive surgical procedure coupled with a rapid rehabilitation protocol and found clients were able to return to driving six days after surgery.

Table of the Quality of Evidence	
Rapid Rehabilitation and Recovery With Minimally Invasive Total Hip Arthroplasty (Berger, Jacobs, Meneghini, Della Valle, Paprosky, & Rosenberg, 2004)	
Objective	Assess potential recovery rate and return to function following hip surgery.
Level/Design Participants	100 patients prospectively enrolled in study of surgical and rehabilitation protocol.
Intervention and Outcome Measurement	A minimally invasive surgical total hip arthroplasty (THA[234]) followed by rapid progression through rehabilitation.
Results	The average time to drive for the 98 patients who drove was 6 days compared to 4 to 8 weeks using old surgical and rehabilitation techniques.
Limitations	None

Table of the Quality of Evidence	
Improvement in Driving Reaction Time After Total Hip Arthroplasty[233] (Ganz, Levin, Peterson, & Ranawat, 2003)	
Objective	Determine rate of improvement in driving reaction time after total hip arthroplasty

	and determine when driving reaction time after total hip arthroplasty returns to preoperative values.
Level/Design Participants	Repeated measures of brake reaction time among 90 individuals with total hip arthroplasty trial (52 right hip; 38 left hip).
Intervention and Outcome Measurement	Preoperative and serial postoperative (1 week, 4 to 6 weeks, 26 weeks, and 52 weeks) partial task measures of break reaction time using the AAA brake reaction timer.
Results	Mean reaction time was slower 1 week after surgery. Reaction time improved at 4 to 6 weeks ($p<.001$), 26 weeks ($p<.001$), and 52 weeks ($p<.001$) and was faster than the preoperative reaction time. Mean reaction times: Preoperative .56 ± .12 1 week post .59 ± .22 4 to 6 weeks post .50 ± .09 26 weeks post .45 ± .06 52 weeks post .48 ± .08
Limitations	Hip pain and muscle strength were not addressed in this study. Only brake reaction time considered, not driving performance or safety.

Other Considerations:

Individuals who have undergone hip replacement surgery may be facing a period of time with compromised weight-bearing status, observance of hip precautions, or any number of co-morbid[235] diagnoses. The individuals may be using prescription or over-the-counter medication to alleviate pain and therefore all medication contraindications[80] should be considered, including drowsiness and medication interactions. In addition, factors other than reaction time should be considered prior to resuming driving, including pain and weight-bearing status.

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:

Advice regarding when to resume driving should be determined by side of surgery, invasiveness of surgical procedure, time for adherence, and total hip arthroplasty precautions.

Chapter 5: Temporary Conditions

Knee Arthroplasty

A person who has undergone knee arthroplastic surgery has all or some of the parts of the knee joint replaced to reconstruct a joint deteriorated from arthritis. Many individuals must adhere to weight-bearing precautions that limit the amount of force that can push up through the knee that might become necessary during hard braking. The functional implications of knee arthroplasty are transferring in and out of the vehicle, operating the accelerator and the brake (with right knee surgery) and operating the clutch or emergency brake (with left knee surgery).

Review of Evidence on Driver Safety and Performance With Respect to Knee Arthroplasty[233]:

Driver Safety: The literature review was unable to identify any study that examines the relationship between drivers with knee arthroplasty and safety, specifically motor vehicle collisions, injurious crashes, fatal crashes, or violations.

Driver Performance: Person, Earles, and Wood (2003) studied the rate at which reaction time returned following total knee arthroplastic surgery and found that reaction time returned to the preoperative level three weeks following surgery and surpassed preoperative reaction time nine weeks after surgery.

Table of the Quality of Evidence	
Brake Response Time After Total Knee Arthroplasty: When Is It Safe for Patients to Drive? (Pierson, Earles, & Wood, 2003)	
Objective	Compare pre- and post-operative brake response times among patients with knee surgery to determine when safe driving can resume.
Level/Design Participants	Repeated measure of brake reaction time among 31 individuals with total knee arthroplasty (13 bilateral, 18 unilateral).
Intervention and Outcome Measurement	Pre-operative and serial post-operative (3 weeks, 6 weeks, and 9 weeks) partial task measures of break reaction time using the AAA brake reaction timer.
Results	Brake response time significantly improved post-operatively at 6 weeks (12.5%) and again at 9 weeks (17.5%). Results suggest resumption of driving is safe after 6 weeks.
Limitations	Small sample size, no control group.

Other Considerations:
Individuals who have undergone knee replacement surgery may be facing a period of time with compromised weight-bearing status or any number of co-morbid[235] diagnoses. The individuals may be using prescription or over-the-counter medication to alleviate pain and therefore all medication contraindications[80] should be considered, including drowsiness and medication interactions. In addition, factors other than reaction time should be considered prior to resuming driving, including pain and weight-bearing status.

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:

Heath care practitioners should use caution when considering the results of this single study in making recommendations regarding driving.

Appendix A

References for Chapter 4: Medical Conditions

Dementia

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Appendix B

Example Medical Examination Form for a Driver License by a Private Physician

Introduction

In order to obtain a driver's medical information and history, which allows DMVs[4] to make decisions about a drivers ability to safely operate a motor vehicle, DMVs must rely on the driver's private physician. The following model Medical Examination Form for a Driver License by a Private Physician was developed to assist DMVs to gather information regarding conditions and suggested diagnosis that may affect driving safely. The form or portions of this form may be used when jurisdictions are developing a form to acquire driver's relevant medical conditions.

EXAMPLE MEDICAL EXAMINATION FORM FOR A DRIVER LICENSE BY A PRIVATE PHYSICIAN

All fees related to completing this form must be assumed by the individual who is undergoing the examination and are not reimbursable to the Department of Motor Vehicles

Driver's Name: _____

Address: _____ Date of Birth: _____

Driver License Number: _____

Telephone Number: _____ Email Address: _____

PERSON UNDERGOING THE MEDICAL EXAMINATION

Read and sign the authorization below.
Take note of the statement regarding protection of personal information at the bottom of page 4.

I, the undersigned, hereby authorize the department of motor vehicle to discuss, when necessary, medical information concerning me with the physician who signs this form. I understand that a summary of all communication will be kept on file**.**

Signature of the person undergoing the medical examination _____
Date _____
mm/dd/yyyy

PHYSICIAN

The examination must take into account prior and current conditions that may affect the individual's ability to drive. A list of relevant disorders is provided at the top of each section. **Any disorder that does not appear in the list must be indicated in section 10**. **This driver is being referred by the DMV due to** _____

SECTION 1: VISION DISORDERS

For Example: *Glaucoma, cataracts, abnormal field of vision, etc*.

Diagnosis:

_____

Wear contacts or glasses for correcting vision for driving: ☐ Yes ☐ No

Visual acuity based upon eye chart with present correction for driving: OD _____OS _____OU_____

Can be omitted if patient has been referred to an ophthalmologist or optometrist.
With correction information is required on if glasses or contacts lenses are needed for driving.

Confrontation field: ☐ Normal ☐ Abnormal **Diplopia:** ☐ Yes ☐ No

Check box if there is no health disorder to declare in this section ☐

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EXAMPLE MEDICAL EXAMINATION FORM FOR A DRIVER LICENSE BY A PRIVATE PHYSICIAN

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SECTION 2: HEARING DISORDERS

For Example: *Hearing loss*

Diagnosis: _____

Hearing loss: ☐ Right ear ☐ Left Ear

Check box if there is no health disorder to declare in this section ☐

SECTION3: NEUROLOGICAL DISORDERS

For Example: *Parkinson's, MS, Epilepsy, syncope, CVA/TCI, brain aneurysm, arteriovenous malformation, Alzheimer's head trauma, brain tumor, cognitive disabilities, etc.*

Diagnosis:

_____

If functional limitations are related to diagnosis complete section 8

Epilepsy: ☐ Yes ☐ No ►If yes, date of first seizure_____
mm/dd/yyyy

Date of last seizure _____
mm/dd/yyyy

Non–epileptic seizures: ☐ Yes ☐ No ►If yes, cause_____

Date of last seizure _____
mm/dd/yyyy

Description of Seizures:_____

Dizziness: ☐ Yes ☐ No ►If yes, Length of episode:_____Disabling? ☐ Yes ☐ No

Check box if there is no health disorder to declare in this section ☐

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SECTION 4: HEART AND VASCULAR DISORDERS

For Example: *Unstable angina, aneurysm> 5.5cm, inability to tolerate exertion, etc*

Diagnosis: _____

Functional Classification
- ☐ I**.** No limitation of physical activity: no symptoms during activities
- ☐ II**.** Slight limitation of physical activities: comfortable at rest or during light physical activities
- ☐ III. Marked limitation of physical activity: comfortable only at rest
- ☐ IV. Must be at complete rest, or confined to bed or chair: any type of physical activity causes discomfort and symptoms can occur even at rest.

Angina: ☐ Yes ☐No ► If yes, unstable? ☐ Yes ☐ No
Arrthymia: ☐ Yes ☐ No
Defibrillator: ☐ Yes ☐ No ► If yes, _____ _____
date of implementation date of last shock

_____
last equipment inspection

Loss of consciousness ► _____ ► Cause _____
Date

Treatment _____

High Blood Pressure: ☐ Yes ☐No ► If yes, Indicate normal B/P _____

Aortic Aneurysm (non surgical treatment) ☐Abdominal ☐ Thoracic

► Diameter _____cm _____
date of ultrasound

Check box if there is no health disorder to declare in this section ☐

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SECTION 5: RESPIRATORY AND SLEEP DISORDERS

For Example: *Severe asthma, oxygenotherapy, sleep apnea, etc*

Diagnosis: _____

Functional Category
- ☐ 1. Presence or absence of shortness of breath; If short of breath, it is attribute to non respiratory causes
- ☐ 2. Shortness of breath when walking rapidly on flat terrain or when climb a slope
- ☐ 3. Shortness of breath when waling on flat terrain compared to an individual of the same age or when climbing stairs.
- ☐ 4. Shortness of breath after walking 100 yards at own pace on flat terrain.
- ☐ 5. Shortness of breath when dressing, when undressing or when speaking.

Oxygenotherapy: ☐ Yes ☐ No ► If yes, ☐ Nighttime ☐ Daytime

Sleep Apnea: ☐ Yes ☐ No ► if yes, treatment effective? ☐ Yes ☐ No
Daytime Drowsiness ☐ Yes ☐ No

Check box if there is no health disorder to declare in this section ☐

SECTION 6: DIABETES AND METABOLIC DISORDERS

For Example: *Poorly Controlled Diabetes, Hypoglycemia, graves disease, Addison's disease thyroid problem, etc.*

Diagnosis:_____

If diabetes is present, does the individual have a proper understanding of and control of diabetes? ☐ Yes ☐ No

Type of diabetes: ☐ I ☐ II **Treatment** : ☐ Insulin ☐ Oral Hypoglycemic medication ☐ Diet

Symptomatic episode of hypoglycemia require action of a third party over the last six months? ☐ Yes ☐ No

If yes, How many? _____ Date of last episode _____

Check box if there is no health disorder to declare in this section ☐

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SECTION 7: PSYCHIATRIC DISORDERS AND SUBSTANCE ABUSE

For Example: *Aggressiveness, behavior disorders, personality disorders, depression, anxiety, abuse or dependence (alcohol drugs or medication) improper uses (alcohol, alcohol + cannabis, medication, drugs) benzodiazepines use, etc.*

Diagnosis: according to DSM IV: _____

Global assessment of function (GAF) scale according to DSM IV _____

Date of last psychotic episode _____ Number of episodes in last year_____
mm/dd/yyyy

Number of episodes in the last 3 years_____

Based upon DSM IV: Is the condition under control? ☐ yes ☐ No

Substance abuse ☐ yes ☐ No

► If yes, which substance? _____

Substance dependence ☐ yes ☐ No

► If yes, which substance? _____

Date of abstinence _____
mm/dd/yyyy

Substance use (amount, how frequently, since when):

_____

_____

Check box if there is no health disorder to declare in this section ☐

SECTION 8: PHYSICAL AND COGNITIVE FUNCTIONAL LIMITATIONS

For Example: *Physical limitation, amputation, congenital deformity, dementia, cognitive impairments, etc.*

Diagnosis:_____

Is this individual's movement limited? ☐ Yes ☐ No ► If Yes, describe the limitation _____

_____

_____

Does this individual wear prosthesis or an orthotic? ☐ Yes ☐ No ► If Yes, specify _____

Have you noticed a change over the past 12 months?

In physical functions**?** ☐ Yes ☐ No ► If Yes, specify _____

In cognitive functions**?** ☐ Yes ☐ No ► If Yes, specify _____

Check box if there is no health disorder to declare in this section ☐

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SECTION 9: CURRENT MEDICATIONS

For Example: *Side effects, interaction of medication, polypharmacy, etc.*

List medications that are used regularly and specify dosage.

Name of RX	Dosage	Frequency

When the individual takes medication, does he/she experience side effects that affect his/her ability to safely operate a motor vehicle?

☐ Yes ☐ No ►If Yes, what type _____

Check box if there is no health disorder to declare in this section ☐

SECTION 10: OTHER DIAGNOSES

Reduced GAF, HA/ADL difficulties, deterioration of general health, Alzheimer's, morbid obesity, dialysis/kidney failure, etc.

Diagnosis: _____
_____

Diagnosis: _____
_____

Diagnosis: _____
_____

SECTION 11: RECOMMENDATIONS

Does the patient understand the risk concerning how the condition impacts safe driving?

☐ Yes ☐ No

In your opinion, should the DMV require this individual to submit to additional assessments?

☐ Yes ☐ No

In your opinion, is the physical impairment or condition likely to have a significant effect on safe driving? ☐ Yes ☐ No ►If yes, what type?

- On-road assessment by the DMV: ☐ Yes ☐ No ►If yes, specify in Additional Comments
- Functional assessment by occupational therapist: ☐ Yes ☐ No ►If yes, specify in Additional Comments
- Specialized consultations: ☐ Yes ☐ No ►If yes, which specialties? _____

Should this individual cease driving while awaiting these assessments? ☐ Yes ☐ No

►If yes, specify in Additional Comments

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SECTION 12: ADDITIONAL COMMENTS

Describe the situations that suggest risk when driving a road vehicle.

_____
_____
_____
_____
_____
_____
_____
_____

SECTION 13: PHYSICIAN/HEALTH CARE PROVIDER INFORMATION

☐ I have been this individual's attending Health Care provider/ physician for _____years

Number of consultations each year? _____

☐ I am not this individuals attending physician. His/her physician is _____

Is the patient being treated by any other physician or specialist? ☐ Yes ☐ No

►If Yes, what kind of specialist_____

☐ This individual does not have an attending physician _____

<table>
<tr><td rowspan="3">Name and address of physician
(in block letters)
_____
_____
_____</td><td colspan="2">Signature</td><td>License no.</td></tr>
<tr><td>Date of examination</td><td>Date of report</td><td>Telephone no.</td></tr>
<tr><td colspan="2">Email</td><td>Fax no.</td></tr>
</table>

Attach any documents you feel are relevant to the case

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Appendix C

Alternate Viewpoint on Assessing Driver Fitness

The American Diabetes Association objects to significant elements of the guidance related to diabetes. Key points raised by the ADA that conflict with the Driver Fitness Working Group guidance include: (1) the ADA feels that it is only necessary for those who have experienced a hypoglycemic event that required third-party intervention (defined as requiring another person to actively administer a carbohydrate, glucagon, or other resuscitative ations) within the last three months to be evaluated and monitored by the DMV; (2) the ADA believes that the guidance is open to too much subjectivity on the part of DMV administrators, clinicians, and drivers; (3) the ADA believes that the treating clinician is best positioned to determine whether the patient presents a driving risk; (4) the ADA feels that it is inappropriate to conclude that hypoglycemic unawareness is always incompatible with driving; (5) the ADA feels that relying on a specified blood glucose level in determining whether to issue a license is inappropriate; and (6) the ADA believes that the research presented does not adequately suggest that complications from diabetes can be appropriately managed, and more recent research should be included. The DFWG did not agree with these points and maintains that the guidance provided in this document is appropriate to help driver licensing administrators in their decisions related to drivers with diabetes. Please note that the rationale for each point of guidance is included in Chapter 4. A brief description of each general concern raised by the ADA follows, paired with the DFWG reasoning for its guidance.

Generally, the American Diabetes Association asserts that it is unnecessary and costly to review case information for all drivers with diabetes, and that focus should instead be on those drivers who have experienced a hypoglycemic event that required third-party intervention, as they are deemed to be at greatest risk of crash involvement. The DFWG believes it is important to evaluate and monitor all drivers with diabetes. Increased crash risk is not limited to drivers who have experienced a hypoglycemic event, and in fact extends to all drivers with diabetes. Periodic controls, such as the submission of medical forms that are completed by clinicians, are a reasonable means of monitoring drivers who are at increased risk of crashing.

The American Diabetes Association expresses concern about ambiguous language in the guidance. In particular, it finds statements such as “free from hypoglycemic episodes,” “compliant with diabetes therapy,” “stable,” and “under control” to be subjective, unnecessarily broad, and without definition in the diabetes medical community. The DFWG opts to keep the guidance as it is in order to meet the needs of driver licensing administrators. The DFWG believes that the language is appropriate to convey the meaning and intent of the guidance to a non-medical audience. It also believes that the language can serve as a framework around which sound policy can be structured, with specific approaches to be adopted at the State level.

ADA does not agree with the DFWG that all hypoglycemic unawareness is incompatible with safe driving. In support of this, ADA notes that literature shows that a two- to three-

week period of scrupulous avoidance of hypoglycemia is enough to regain hypoglycemic awareness. In addition, ADA suggests that a person with hypoglycemia unawareness may still be safe to drive with proper precautions, including testing blood glucose before driving and testing at least hourly on long drives. The DFWG suggests that it is important to review the case of each person who may be at increased risk of a crash, and that people with hypoglycemic unawareness fall into this category.

The American Diabetes Association recommends that the responsibility for determining whether an individual is safe to drive be focused on the treating clinician rather than the DMV. The DFWG recommends that licensing fitness decisions remain with licensing aministrators with input from treating clinicians. The DFWG opts to provide guidance that driver licensing administrators can use in working with clinicians regarding driving safety. The relationship between the DMV and clinicians should be a balanced one where both parties contribute their own expertise while respecting that of the other party.

The ADA disagrees with the requirement that, in order to qualify for a license, people with diabetes must be free of a pattern of repeated episodes of hypoglycemia where their blood glucose levels are 45 mg/dL or less. The ADA believes that a requirement that the clinician certify that the individual has not had an episode of hypoglycemia requiring intervention from another person is sufficient and that relying on a specified blood glucose level as a measure of safety risk is unreliable due to individual differences.

Finally, the American Diabetes Association believes that the research findings presented in Chapter 4 are incomplete, and that they inadequately state the manageability of the disease. The DFWG believes that the research findings presented in Chapter 4 suggest that complications from diabetes can be appropriately managed, but that the management should also include monitoring by the DMV. The American Diabetes Association also suggests that research from the last year that it published be included. From a practical perspective, this is not feasible. The DFWG suggests that available research was considered at the time of the review and that these guidelines should be revisited periodically as new research findings become available.

For further information and clarificationson these ADA positions, we encourage driver licensing administrators to contact the American Diabetes Association.

Glossary

[1] **NHTSA** – National Highway Traffic Safety Administration
[2] **AAMVA** – American Association of Motor Vehicle Administrators
[3] **DFWG** – Driver Fitness Working Group
[4] **DMV** – Department of Motor Vehicles
[5] **visual acuity** is the ability to distinguish details and shapes of objects
[6] **visual field** refers to one's entire spatial area of vision when fixation is stable, and includes both central and peripheral vision
[7] **dementia** is a loss of mental ability severe enough to interfere with normal activities of daily living, lasting more than six months, not present since birth, and not associated with a loss or alteration of consciousness.
[8] **psychoactive medication** is a substance that effects emotional and psychological perception in the brain
[9] **benzodiazepines** are central nervous system depressant medications used to relieve nervousness, tension, and other symptoms. Benzodiazepines are commonly used to treat anxiety disorders. These medications can cause drowsiness.
[10] **neuroleptics** are antipsychotic drug that are used to treat mental disorder characterized by symptoms such as delusions or hallucinations that indicate impaired contact with reality.
[11] **antidepressants** are medications prescribed to relieve major depression
[12] **Alzheimer's disease** is a degenerative brain disease of unknown cause that is the most common form of dementia. The disease usually starts in late middle age or in old age as a memory loss for recent events spreading to memories for more distant events and progressing over the course of five to ten years to a profound intellectual decline.
[13] **AD** – Alzheimer's disease
[14] **hypoglycemia** is low blood sugar that occurs quickly. Hypoglycemia occurs when blood sugar (or blood glucose) concentrations fall below a level necessary to properly support the body's need for energy and stability throughout its cells.
[15] **diabetes** is a disease in which the body does not properly use or produce enough insulin, resulting in elevated blood glucose
[16] **epilepsy** is the common medical disorder characterized by recurrent seizures
[17] **seizure** is a sudden alteration in behavior that may range from loss of consciousness or body control to a mild subjective feeling, due to acute abnormal brain electrical activity
[18] **obstructive sleep apnea** is a potentially life-threatening condition characterized by episodes of breathing cessation during sleep alternating with snoring or disordered breathing. The low levels of oxygen in the blood of patients with OSA may eventually cause heart problems or stroke.
[19] **OSA** – obstructive sleep apnea
[20] **apnea hypopnea index** is an index of severity that combines apneas and hypopneas. Combining them both gives an overall severity of sleep apnea including sleep disruptions and desaturations (a low level of oxygen in the blood). The apnea-

hypopnea index is calculated by dividing the number of apneas and hypopneas by the number of hours of sleep.

[21] **AHI** – apnea hypopnea index

[22] **narcolepsy** is a disorder marked by excessive daytime sleepiness, uncontrollable sleep attacks, and cataplexy (a sudden loss of muscle tone, usually lasting up to half an hour)

[23] **stroke or cerebral vascular accident** is the sudden death of some brain cells due to lack of oxygen when the blood flow to the brain is impaired by blockage or rupture of an artery to the brain

[24] **traumatic brain injury** is brain damage from trauma

[25] **contrast sensitivity** refers to the amount of contrast a person needs in order to detect or identify an object or pattern, it is the visual ability to see objects that may not be outlined clearly or that do not stand out from their background.

[26] **Trails A and B Tests** often called the Trail-Making Tests or TMT are popular tests that are recommended by the American Medical Association for older driver screening. The tests are designed to screen the cognitive function of an individual and monitor subjects for cognitive decline, brain injury, or cognitive impairment. The test consists of two parts; The Trail Making Test Part A, consisting of 25 circles numbered 1-25 and the patient has to draw lines to connect the numbers in ascending order and The Trail Making Test Part B, consisting of 25 circles including both numbers (1-13) and letters (A-L) and the patient has to draw lines to connect the circles alternating between the numbers and letters (i.e., 1-A, 2-B, 3-C, etc.).

[27] **Mini Mental Status Exam** is a brief 30-point questionnaire test that is used to screen for cognitive impairment. It is commonly used in medicine to screen for dementia. It is also used to estimate the severity of cognitive impairment at a given point in time and to follow the course of cognitive changes in an individual over time, thus making it an effective way to document an individual's response to treatment.

[28] **MMSE** – Mini Mental Status Exam

[29] **insulin** is a hormone that is needed to convert sugar, starches, and other food into energy needed for daily life

[30] **anti-epileptic drugs** are drugs used to treat or prevent convulsions (as in epilepsy)

[31] **AED** – anti-epileptic drugs

[32] **neurological** has to do with the nerves or the nervous system

[33] **The Diagnostic and Statistical Manual of Mental Disorders** is published by the American Psychiatric Association and provides diagnostic criteria for mental disorders. It is used in the United States and in varying degrees around the world, by clinicians, researchers, psychiatric drug regulation agencies, health insurance companies, pharmaceutical companies and policy makers.

[34] **DSM-IV** – Diagnostic and Statistical Manual of Mental Disorders

[35] **continuous positive airway pressure** is an effective treatment for obstructive sleep apnea. CPAP patients during sleep wear a face mask connected to a pump that forces air into the nasal passages at pressures high enough to overcome obstructions in the airway and stimulate normal breathing. The airway pressure delivered into the upper airway is continuous during both inspiration and expiration.

[36] **CPAP** – continuous positive airway pressure

[37] **neuromuscular disease** is a very broad term that encompasses many diseases and ailments that either directly, via intrinsic muscle pathology, or indirectly, via nerve pathology, impair the functioning of the muscles

[38] **amputation** is the absence of a limb due to a congenital limb deficiency or surgical removal of a limb following trauma or illness

[39] **congenital** involves defects or damage to a developing fetus

[40] **transtibial** is an amputation above the foot but below the knee

[41] **rheumatoid arthritis**: is an autoimmune disease that causes chronic inflammation of the joints, the tissue around the joints, as well as other organs in the body. Autoimmune diseases occur when the body tissues are mistakenly attacked by its own immune system.

[42] **RA** – rheumatoid arthritis

[43] **osteoarthritis** is a type of arthritis caused by inflammation, breakdown, and eventual loss of cartilage in the joints

[44] **OA** – osteoarthritis

[45] **sciatica** is pain resulting from irritation of the sciatic nerve. Sciatica pain is typically felt from the low back to behind the thigh and radiating down below the knee. The sciatic nerve is the largest nerve in the body and begins from nerve roots in the lumbar spinal cord in the low back and extends through the buttock area to send nerve endings down the lower limb.

[46] **fibromyalgia** is a chronic disorder characterized by widespread pain, tenderness, and stiffness of muscles and associated connective tissue structures that is typically accompanied by fatigue, headache, and sleep disturbances

[47] **FM** – fibromyalgia

[48] **ankylosing spondylitis** is a form of chronic inflammation of the spine and the sacroiliac joints. The sacroiliac joints are located in the low back where the sacrum (the bone directly above the tailbone) meets the iliac bones (bones on either side of the upper buttocks). Chronic inflammation in these areas causes pain and stiffness in and around the spine. Over time, chronic spinal inflammation (spondylitis) can lead to a complete cementing together (fusion) of the vertebrae, a process referred to as ankylosis. Ankylosis leads to loss of mobility of the spine.

[49] **AS** – ankylosing spondylitis

[50] **in vivo** means in the living organism, as opposed to in vitro (in the laboratory)

[51] **CVA** – cerebral vascular accident

[52] **hemiparesis** is weakness on one side of the body

[53] **paresis** is slight or incomplete paralysis

[54] **multiple sclerosis** is a progressive neurological disorder of unknown origin that affects vision (double vision), cognition (problem solving, attention, and memory), sensation, and physical strength

[55] **MS** – multiple sclerosis

[56] **MSFC** – Multiple Sclerosis Functional Composite

[57] **NDT** – neurocognitive driving test

[58] **Parkinson's disease** is a progressive neurological disorder that characterized by tremors, rigidity, slow movements and posture instability

[59] **akinesia** is an absence, poverty, or loss of control of voluntary muscle movements

[60] **tremors** are an unintentional (involuntary), rhythmical alternating movement that may affect the muscles of any part of the body, which is caused by the rapid alternating contraction and relaxation of muscles and is a common symptom of diseases of the nervous system

[61] **dyskinesia** is an impairment in the ability to control movements, characterized by spasmodic or repetitive motions or lack of coordination

[62] **bradykinesia** is extreme slowness in movement

[63] **hallucinations** are false or distorted sensory experiences that appear to be real perceptions. These sensory impressions are generated by the mind rather than by any external stimuli, and may be seen, heard, felt, and even smelled or tasted.

[64] **PD** – Parkinson's disease

[65] **The Unified Parkinson's Disease Rating Scale** is a rating tool to follow the longitudinal course of Parkinson's disease. It is made up of the (1) mentation, behavior, and mood, (2) activities of daily living and (3) motor sections. These are evaluated by interview. Some sections require multiple grades assigned to each extremity. A total of 199 points are possible. 199 represents the worst (total) disability, 0 represents no disability.

[66] **UPDRS** – Unified Parkinson's Disease Rating Scale

[67] **Webster's Rating Scale** is an assessment of the severity of Parkinson's disease and clinical impairment against 10 items using a scale of 0 = normal to 3 = maximum impairment: bradykinesia, rigidity, posture, upper extremity swing, gait, tremor at rest, facies, seborrhoea, speech, and self care.

[68] **The Stroke Driver Screening Assessment (SDSA)** is used to predict the driving performance of individuals following a stroke. Therapists use the set of tests to identify drivers who are unfit to drive after a stroke. This assessment consists of three tests: road-sign recognition, a concentration task, and a verbal-reasoning task. The SDSA has been used to test the cognitive abilities of patients with neurological disabilities, including dementia.

[69] **SDSA** – Stroke Driver Screening Assessment

[70] **The Adult Memory and Information Processing Battery** is a test of the speed of information processing in patients with multiple sclerosis

[71] **AMIPB** – The Adult Memory and Information Processing Battery

[72] **msec** – millisecond

[73] **The Hoehn and Yahr Staging Scale** is a commonly used system for describing how the symptoms of Parkinson's disease progress. The scale allocates stages from 0 to 5 to indicate the relative level of disability.

[74] **The Finger Tapping Test** is a neuropsychological test that assesses motor speed and motor control

[75] **neuropsychological** is a discipline combining neurology and psychology to study the relationship between the functioning of the brain and cognitive processes or behavior

[76] **route following task** is a test that measures visual and cognitive abilities that are critical to safe automobile driving. At the beginning of the test the driver is required to recite and learn correctly a brief set of verbal directions to a destination. Then the driver is tested on the number of (a) incorrect turns, (b) times lost, and (c) at-fault safety errors during the task.

[77] **RFT** – route following task

[78] **aiming task** is a test in which the coordination of eye and hand movements is measured when a subject attempts to catch up with a visual target

[79] **The Purdue Pegboard Test** has been used extensively to aid in the selection of employees for jobs that require fine and gross motor dexterity and coordination. It measures gross movements of hands, fingers and arms, and fingertip dexterity as necessary in assembly tasks.

[80] **contraindications** means to indicate the inadvisability of something, such as a medical treatment

[81] **cervical** pertains to the neck

[82] **thoracic** pertains to the thorax or chest

[83] **lumbar** pertains to the lower back

[84] **TBI** – traumatic brain injury

[85] **SPI** – Simulator Performance Index

[86] **DPI** – Driver Performance Inventory

[87] **premorbid** means occurring before development of disease

[88] **The Functional Independence Measure** is an 18-item, seven-level ordinal scale. It is the product of an effort to resolve the long standing problem of lack of uniform measurement and data on disability and rehabilitation outcomes. The FIM can be completed in approximately 20-30 minutes in conference, by observation, or by telephone interview. It assesses areas of dysfunction in activities that commonly occur in individuals with any progressive, reversible or fixed neurologic, musculoskeletal and other disorders. One limitation relative to using the FIM in evaluating survivors of TBI is that it is not diagnosis-specific. Although found to be reliable and valid, the scale has few cognitive, behavioral, and communication related functional items relevant to assessing people with TBI.

[89] **FIM** – Functional Independence Measure

[90] **The Functional Assessment Measure** was developed as an adjunct to the FIM to specifically address the major functional areas that are relatively less emphasized in the FIM, including cognitive, behavioral, communication and community functioning measures. The FAM consists of 12 items. These items do not stand alone, but are intended to be added to the 18 items of the FIM. The total 30 item scale combination is referred to as the FIM+FAM. The time required to administer the FIM+FAM is approximately 35 minutes.

[91] **FAM** – Functional Assessment Measure

[92] **macular degeneration** is a disease associated with aging that in its advanced stages causes a serious loss of central vision including visual acuity impairment

[93] **cataract** refers to an increased opacification of the lens in the eye. The lens becomes cloudy thus causing objects and patterns to look washed out, blurry, and indistinct.

[94] **optic neuritis** is a vision disorder characterized by inflammation of the optic nerve

[95] **glaucoma** is a common eye condition in which the fluid pressure inside the eyes rises because of slowed fluid drainage from the eye. It causes visual field impairment and in its advanced stages it can also lead to a loss of central vision including impaired visual acuity.

[96] **retinitis pigmentosa** refers to a group of inherited disorders that slowly lead to blindness due to abnormalities of the photoreceptors (primarily the rods) in the retina.

[97] **Stargardt's disease** is an inherited disorder that affects children and young adults. Stargardt's generally refers to a group of inherited diseases causing light-sensitive cells in the inner back of the eye (retina) to deteriorate, particularly in the area of the macula where fine focusing occurs. Central vision loss also occurs, while peripheral vision usually is retained.

[98] **diabetic retinopathy** is a vascular complication of both type 1 and type 2 diabetes where blood vessels in the eye swell and leak or abnormal new blood vessels grow

[99] **optic atrophy** is a degeneration of the optic nerve fibers that can lead to a loss of clarity, changes in the field of vision or both

[100] **cornea** refers to the transparent, convex, anterior portion of the outer fibrous coat of the eyeball that covers the iris and the pupil and is continuous with the sclera

[101] **amblyopi**a is a disorder of the visual system that is characterized by poor or indistinct vision in an eye that is otherwise physically normal, or out of proportion to associated structural abnormalities. It has been estimated to affect 1 to 5 percent of the population. The problem is caused by either no transmission or poor transmission of the visual image to the brain for a sustained period of dysfunction or during early childhood

[102] **uncorrected refractive error** is an optical defect of the eye that results in light not being focused clearly on the retina.

[103] **myopia** or nearsightedness affects 20 percent to 30 percent of the population, but this eye disorder is easily corrected with eyeglasses, contact lenses or surgery. People who have myopia or nearsightedness have difficulty seeing distant objects, but can see objects that are near, clearly.

[104] a **bioptic telescope** looks like a standard pair of glasses with a small telescope attached to the top of the frames. It is portable and light-weight, yet it automatically magnifies images to four time's normal size when looking at an object at a distance and five times normal size in close range. The bioptic telescope magnifies distant objects; drivers with this device are taught to use their carrier lens most of the time and glance through the telescope for only a few seconds at a time to read a road sign or street name.

[105] **contrast** refers to the light-dark transition at the border or the edge of an image or object that defines the existence of a pattern or an object

[106] **contrast sensitivity impairment** is the inability to detect or identify an object or pattern clearly. A person with contrast sensitivity impairment sees objects as having very little distinction between boundaries.

[107] **preponderance** is a superiority in weight, power, importance, or strength

[108] **central vision** refers to straight-ahead vision. Central vision permits a person to read, drive, and perform other activities that require fine, sharp, straight-ahead vision.

[109] **peripheral vision** refers to side vision. It is the ability to see objects and movement outside of the direct line of vision. Peripheral vision is the work of the rods, nerve cells located largely outside the macula (the center) of the retina. The rods are also responsible for night vision and low-light vision but are insensitive to color.

[110] **visual field impairment** is having reduced vision that constitutes a significant limitation of visual capability resulting from disease, trauma, or a congenital or degenerative condition that cannot be corrected by conventional means

[111] **color vision deficit** refers to impairment in the ability to discriminate among colors, and can either be inherited, or acquired later in life

[112] **The Federal Motor Carrier Safety Administration** was established as a separate administration in the U.S. Department of Transportation on January 1, 2000, pursuant to the Motor Carrier Safety Improvement Act of 1999. Its primary mission is to reduce crashes, injuries, and fatalities involving large trucks and buses.

[113] **FMCSA** – Federal Motor Carrier Safety Administration

[114] **slowed visual processing speed** refers to a slowing in the speed at which a person processes visual information, particularly as related to recognizing and identifying objects and patterns and making decisions about them

[115] **hemianopia** is a visual field impairment where complete or near complete loss of light sensitivity occurs in one half of the visual field on the same side in visual space

[116] **quadrantanopia** refers to the loss of sensitivity in one-quarter (or one quadrant) of the visual field.

[117] **AMD** – age-related macular degeneration

[118] **opacification** is the process of becoming or rendering opaque (impervious to light rays, x-rays or other electromagnetic radiation), the rendering opaque for x-rays of a tissue or organ by introduction of a contrast medium

[119] **delirium** is an acute and relatively sudden (developing over hours to days) decline in attention-focus, perception, and cognition. Delirium is not the same as dementia, though it commonly occurs in demented patients.

[120] **neurodegenerative disorder** is a type of neurological disease marked by the loss of nerve cells

[121] **viral encephalitis** is inflammation of the brain as a result of a virus infection

[122] **syphilis** is an infectious systemic disease that may be either congenital or acquired through sexual contact or contaminated needles

[123] **HIV/AIDS** – Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome is a set of symptoms and infections resulting from the damage to the human immune system caused by the human immunodeficiency virus (HIV). This condition progressively reduces the effectiveness of the immune system and leaves individuals susceptible to opportunistic infections and tumors. HIV is transmitted through direct contact of a mucous membrane or the bloodstream with a bodily fluid containing HIV, such as blood, semen, vaginal fluid, preseminal fluid, and breast milk.

[124] **metabolic** means relating to, or resulting from metabolism

[125] **hypothyroidism** or underactive thyroid, develops when the thyroid gland fails to produce or secrete as much thyroxine as the body needs. Because thyroxine regulates such essential functions as heart rate, digestion, physical growth, and mental development, an insufficient supply of this hormone can slow life-sustaining processes, damage organs and tissues in every part of the body, and lead to life-threatening complications.

[126] **psychoactive medication** is a substance that effects emotional and psychological perception in the brain

[127] **benzodiazepines** are central nervous system depressant medications used to relieve nervousness, tension, and other symptoms. Benzodiazepines are commonly used to treat anxiety disorders. These medications can cause drowsiness.

[128] **neuroleptics** are antipsychotic drug that are used to treat mental disorder characterized by symptoms such as delusions or hallucinations that indicate impaired contact with reality.

[129] **antidepressants** are medications prescribed to relieve major depression

[130] **Alzheimer's disease** is a degenerative brain disease of unknown cause that is the most common form of dementia. The disease usually starts in late middle age or in old age as a memory loss for recent events spreading to memories for more distant events and progressing over the course of five to ten years to a profound intellectual decline.

[131] **AD** – Alzheimer's disease

[132] **clinical dementia rating scale** is a numeric scale used to quantify the severity of symptoms of dementia

[133] **CDR** – clinical dementia rating scale

[134] **visuospatial** pertains to the ability to understand visual representations and their spatial relationships

[135] **Judgment of Line Orientation Test** is a relatively pure measure of visuospatial perception, analysis, and judgment

[136] **JLO** – Judgment of Line Orientation Test

[137] **block design** is a subtest on many intelligence tests that tests visuospatial and motor skills. The testee is required to take blocks that have all white sides, all red sides, and red and white sides and arrange them according to a pattern. They are timed on this task and compared to a normative sample.

[138] **Benton Visual Retention Test** or "the Benton," as it is usually called, is a widely used instrument that assesses visual perception, visual memory, and visuoconstructive abilities. Because it measures perception of spatial relations and memory for newly learned material, it is used in clinical diagnosis of brain damage and dysfunction in children and adults, as well as in research. The individual is shown 10 designs, one at a time, and asked to reproduce each one as exactly as possible on plain paper from memory. The test is untimed, and the results are professionally scored by form, shape, pattern, and arrangement on the paper.

[139] **BVRT** – Benton Revised Visual Retention Test

[140] **Complex Figure Test** is a test of visual-spatial perception/construction and memory

[141] **CFT** – Complex Figure Test

[142] **Facial Recognition Test** assesses memory, visual recognition, and face processing. The test is successful in identifying face processing impairments.

[143] **tricyclics** are any group of antidepressants that contain three fused benzene rings. They work on three brain neurotransmitters in relieving depression symptoms, such as irritability and anger.

[144] **narcotic analgesics** is a drug derived from opium or opiumlike compounds, with potent painkilling effects associated with significant alteration of mood and behavior, and with the potential for dependence and tolerance following repeated administration

[145] **dopaminergic medications** are activated or transmitted by dopamine, which is a neurochemical made in the brain that is involved in many brain activities, including movement and emotion

[146] **Paced Auditory Serial Addition Task** a measure of rate of information processing, is presented as a convenient test for estimating individual performance during recovery of amnesia or concussions

[147] **PASAT** – Paced Auditory Serial Addition Task

[148] **Controlled Oral Word Association** is a kind of psychological test in which participants have to say as many words as possible from a category in a given time (usually 60 seconds). This category can be semantic, such as fruits, or phonetic, such as words that begin with the letter p

[149] **COWA** – Controlled Oral Word Association

[150] **Huntington's disease** is a genetic neurological disorder characterized after onset by uncoordinated, jerky body movements and a decline in some mental abilities. These characteristics vary per individual, physical ones less so, but the differing decline in mental abilities can lead to a number of potential behavioral problems. The disorder itself isn't fatal, but as symptoms progress, complications reducing life expectancy increase

[151] **The Wisconsin Card Sorting Test** is a neuropsychological test of "set-shifting," i.e., the ability to display flexibility in the face of changing schedules of reinforcement.

[152] **WCST** – Wisconsin Card Sorting Test

[153] **The brief visual memory test - revised** is designed for use as a criterion measure of visuospatial memory within a large battery of neuropsychological tests, as a screening measure within a brief neuropsychological battery, and as a repeat measure to document changes in neurocognitive skills over time. It has been standardized and normed for use with adults 18 to 79 years old.

[154] **BVMT-R** – brief visual memory test - revised

[155] **The Rey Auditory Verbal Learning Test** measures motivational impairment after mild head trauma

[156] **AVLT** – Auditory Verbal Learning Test

[157] **Mattis Organic Mental Syndrome Screening Examination** – an extensive screening exam that estimates the patient's previous level of functioning and comparing this with test results

[158] **MOMSSE** – Mattis Organic Mental Syndrome Screening Examination

[159] **The Short Portable Mental Status Questionnaire** is a brief 10-item tool that screens for the presence and degree of cognitive impairment. It was developed specifically for use with older adults. It can be administered by clinicians in office and hospital settings.
[160] **SPMSQ** – Short Portable Mental Status Questionnaire
[161] **A randomized controlled trial** is a type of scientific experiment most commonly used in testing the efficacy or effectiveness of healthcare services (such as medicine or nursing) or health technologies (such as pharmaceuticals, medical devices or surgery)
[162] **RCT** – randomized controlled trial
[163] **blood glucose** is the main sugar that the body makes from the food in the diet. Glucose is carried through the bloodstream to provide energy to all cells in the body. Cells cannot use glucose without the help of insulin.
[164] **type 2 diabetes** is the most common form of diabetes. In type 2 diabetes, either the body does not produce enough insulin or the cells ignore the insulin.
[165] **type 1 diabetes** is usually diagnosed in children and young adults, and was previously known as juvenile diabetes. In type 1 diabetes, the body does not produce insulin.
[166] **pre-diabetes** occurs before people develop type 2 diabetes, when their blood glucose levels are higher than normal but not yet high enough to be diagnosed as diabetes
[167] **gestational diabetes** occurs when a pregnant woman who has never had diabetes before has high blood sugar (glucose) levels during pregnancy
[168] **pancreatitis** is inflammation of the pancreas, can either be acute or chronic
[169] **hypoglycemic agents** are any various agents that decrease the level of glucose in the blood and are used in the treatment of diabetes
[170] **polyuria** is a condition characterized by the passage of large volumes of urine
[171] **polydipsia** is a medical symptom in which a patient drinks abnormally large amounts of fluids
[172] **hemorrhage** is a large discharge of blood from the blood vessels
[173] **neuropathy** is a functional disturbance or pathological change in the peripheral nervous system
[174] **atherosclerosis** is the build up of a waxy plaque on the inside of blood vessels. It is responsible for most heart disease and is a type of hardening of the arteries
[175] **blood glucose awareness training (BGAT)** is a psycho-educational programmatic intervention designed to improve the accuracy of patients' detection and interpretation of relevant blood glucose symptoms and other cues. BGAT has been shown to improve accuracy of overall recognition of current blood glucose levels as well as to specifically improve detection of hypoglycemia and hyperglycemia.
[176] **BGAT** – blood glucose awareness training
[177] **M.D./D.O.** – medical doctor/osteopathic doctor
[178] **antihyperglycemic therapy** is often necessary to achieve optimal glycemic control in the management of diabetes. Orally administered antihyperglycemic agents (OHAs) can be used either alone or in combination with other OHAs or insulin.
[179] **hypersomnia** is an excessively long sleeping time but is normal in the waking intervals. These person may have daytime sleepiness.

[180] **restless leg syndrome** is an uncomfortable creeping, crawling, tingling, pulling, twitching, tearing, aching, throbbing, prickling or grabbing sensation in the calves that occurs while sitting or while lying down. Whatever the nature of the sensation, the result is an uncontrollable urge to relieve it by moving the legs.

[181] **apnea** is a period of time during which breathing stops or is markedly reduced. Apneas usually occur during sleep, and when they do occur, sleep is usually disrupted. Sometimes the person wakes up completely, but sometimes the person comes out of a deep level of sleep and into a more shallow level of sleep.

[182] **excessive daytime sleepiness** is a neurological disorder in which there is a sudden recurrent uncontrollable compulsion to sleep. Excessive daytime sleepiness is also known as narcolepsy.

[183] **EDS** – excessive daytime sleepiness

[184] **hypoxia** is a pathological condition in which the body as a whole or a region of the body is deprived of adequate oxygen supply

[185] **body mass index** is a measurement of the relative percentages of fat and muscle mass in the human body, in which mass in kilograms is divided by height in meters squared and the result used is an index of obesity

[186] **BMI** – body mass index

[187] **polysomnograph** is a polygraph performed during sleep. Physiological variables such as pulse, blood pressure, and respiration are monitored and charted

[188] **PSG** – polysomnograph

[189] **The Berlin Questionnaire**, developed in 1996, includes a series of questions about risk factors for sleep apnea, including snoring behavior, wake time sleepiness or fatigue, and obesity or hypertension.

[190] **oropharyngeal** pertains to the mouth and pharynx (throat)

[191] **tracheostomy** surgical procedure used to create an opening into the trachea through the neck that allows the insertion of a tube to restore normal breathing

[192] **hypertension** is high blood pressure

[193] **cognitive dysfunction** is the loss of intellectual functions (such as thinking, remembering, and reasoning) of sufficient severity to interfere with daily functioning

[194] **heart disease** is any disorder that affects the heart

[195] **reflux esophogitis** is inflammation of the lower esophagus caused by the backflow of stomach contents

[196] **RDI** – Respiratory Disturbance Index

[197] **ESS** – The Epworth sleepiness scale

[198] **The Epworth sleepiness scale** is a questionnaire intended to measure daytime sleepiness. This can be helpful in diagnosing sleep disorders.

[199] **MSLT** – The Multiple Sleep Latency Test

[200] **The Multiple Sleep Latency Test** (MSLT) is a sleep disorder diagnostic tool. It is used to measure the time it takes from the start of a daytime nap period to the first signs of sleep, called **sleep latency**. The test is based on the idea that the sleepier people are, the faster they will fall asleep.

[201] **MWT** – Multiple Wakefulness Test

[202] **A Multiple Wakefulness Test** is a test usually performed to check CPAP compliance or to ensure optimal treatment of sleep apnea. A MWT is a series of four controlled sessions approximately1.5 hours apart. During the session, the patient sits upright in a darkened room and tries to remain alert. The parameters recorded will help determine the patient's level of alertness.

[203] **uvulopalatopharyngoplasty** is a surgical resection of tissue of the mouth to open the airway, intended to cure extreme cases of snoring.

[204] **febrile seizures** are seizures associated with high fever, and occurr in infants and children

[205] **partial seizures** are a type of seizure that affects only one part of the brain. Symptoms depend on which part is affected. One part of the body, or multiple body parts confined to one side of the body, may start to twitch uncontrollably. Partial seizures may involve head turning, eye movements, lip smacking, mouth movements, drooling, rhythmic muscle contractions in a part of the body, apparently purposeful movements, abnormal numbness, tingling, and a crawling sensation over the skin. Partial seizures can also include sensory disturbances, such as smelling or hearing things that are not there, or having a sudden flood of emotions. Although the patient may feel confused, consciousness is not lost. Also known as a focal seizure or a local seizure.

[206] **simple partial seizures** are a type of seizure where the patient is alert, conscious, and remembers what happened during the event. Depending upon which area the seizure arose from in the brain, behavioral alterations vary between abnormal motor activity such as posturing or twitching, peculiar ideation including déjà vu (the feeling that something that should be unfamiliar has happened before), a feeling of numbness or tingling, or peculiar visual sensations such as flashing lights or even formed hallucinations.

[207] **complex partial seizures** are a type of seizure where consciousness is impaired, and the patient cannot recall what happened

[208] **generalized seizures** are a type of seizure (as an absence seizure or tonic-clonic seizure) that originates in both cerebral hemispheres

[209] **tonic-clonic seizures** are a type of generalized seizure distinguished by a sudden loss of consciousness and involuntary muscle contraction that lasts for a few minutes. People affected may bite their tongues, clench their teeth, and lose control of bodily functions such as defecation or urination. Often the patient has no memory of the event on awakening. Also called grand mal seizure.

[210] **post-ictal** is the time following a seizure

[211] **tonic seizures** are a type of generalized seizure that last 5 to 20 seconds and are characterized by tonic (body becomes rigid) not clonic (uncontrolled jerking) contractions. This type of seizure involves flexion and extension of the trunk, neck, and limbs, often at night.

[212] **absence seizures** are a type of generalized seizure that is marked by transient impairment or loss of consciousness, usually with a blank stare, that begins and ends abruptly (3 to 20 seconds), impairs cognition and awareness without warning or post-ictal confusion and is usually unremembered afterward.

[213] **atypical absence seizures** are a type of generalized seizure that last up to 30 seconds where the person will stare (as they would in any absence seizure) but often is somewhat responsive. Eye blinking or slight jerking movements of the lips may occur. This behavior can be hard to distinguish from the person's usual behavior, especially in those with cognitive impairment. Unlike other absence seizures, these seizures usually cannot be produced by rapid breathing. These seizures last up to 30 seconds, and include staring, and occasional eye blinking and lip twitching

[214] **myoclonic seizures** are a type of generalized seizure involving jerking of the muscles of the neck, trunk, shoulders, upper arms, and upper legs, while conscious

[215] **atonic seizures** are a type of generalized seizure that last up to a minute, and are comprised of sudden loss of body tone, with head nods, jaw drops, falls, and impaired consciousness

[216] **auras** are a premonition. There is often an aura before a migraine or a grand mal seizure. The aura, a symptom of brain malfunction, may consist of flashing lights, a gleam of light, blurred vision, an odor, the feeling of a breeze, numbness, weakness, or difficulty speaking.

[217] **prophylaxis** is a measure taken for the prevention of a disease or condition

[218] **lidocaine** is a common local anesthetic and antiarrhythmic drug. Lidocaine is used topically to relieve itching, burning and pain from skin inflammations, injected as a dental anesthetic, and in minor surgery.

[219] **postconcussive** is a set of symptoms that a person may experience for weeks, months, or occasionally years after a concussion, a mild form of traumatic brain injury

[220] **convulsive syncope** is a brief loss of consciousness caused by a sudden fall of blood pressure or failure of the cardiac systole with convulsive movements that are milder than those seen in epilepsy.

[221] **amnesia** is the loss of memory.

[222] **brain hemorrhage** occurs within the brain tissue itself. It can be caused by brain trauma, or it can occur spontaneously in hemorrhagic stroke.

[223] **encephalitis** is an acute inflammation of the brain. It can be caused by a bacterial infection such as bacterial meningitis spreading directly to the brain (primary encephalitis), or may be a complication of a current infectious disease like rabies or syphilis (secondary encephalitis).

[224] **meningitis** is a medical condition that is caused by inflammation of the protective membranes covering the brain and spinal cord, known collectively as the meninges. The inflammation is usually caused by infection with viruses, bacteria, or other microorganisms but may also arise due to certain drugs, or other diseases. Meningitis is potentially life threatening due to the inflammation's proximity to the brain and spinal cord; it is therefore a medical emergency.

[225] **brain abscess** is an abscess caused by inflammation and collection of infected material coming from local (ear infection, dental abscess, infection of paranasal sinuses, infection of the mastoid air cells of the temporal bone, epidural abscess) or remote (lung, heart, kidney etc.) infectious sources within the brain tissue.

[226] **cysticercosis** is the most common parasitic infestation of the central nervous system worldwide. Humans develop cysticercosis when they ingest eggs or larvae of the

tapeworm Taenia solium. The eggs and larvae are usually found in fecally-contaminated water and undercooked pork.

[227] **anterior cruciate ligament** is one of the large ligaments in the knee that crosses from the underside of the femur (the thigh bone) to the top of the tibia (the bigger bone in the lower leg). It is one of the more frequent injuries of the knee often caused by hyperextension.

[228] **ACL** – anterior cruciate ligament

[229] **comorbidity** is the presence of one or more disorders (or diseases) in addition to a primary disease or disorder

[230] **herniation** is an abnormal protrusion of an organ or other body structure through a defect or natural opening in a covering, membrane, muscle, or bone

[231] **orthosis** is an orthopedic appliance or apparatus used to support, align, prevent, or correct deformities or to improve function of movable parts of the body

[232] **fixator** is a device that provides rigid immobilization of a fractured bone by means of rods attached to pins that are placed in or through the bone

[233] **arthroplasty** is the surgical correction of a joint abnormality

[234] **THA** – total hip arthroplasty

[235] **co-morbid** pertains to a disease or other pathological process that occurs simultaneously with another.

[232] **Useful Field of View test** is a PC-based, computer-administered and scored test of visual attention

[233] **UFOV** – Useful Field of View

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Driver Fitness Medical Guidelines