

**THE NORTH CAROLINA PHYSICIAN'S GUIDE
TO DRIVER MEDICAL EVALUATION**

Second Edition

Medical Review Branch
Driver License Section
Division of Motor Vehicles
North Carolina Department of Transportation

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PREFACE TO THE SECOND EDITION

The primary purpose for publishing a Second Edition of the *Physician's Guide to Driver Medical Evaluation* is to update the scientific evidence for driver medical evaluation. Since the first edition of the *Physician's Guide* was published in June 1995, many new studies of the effects of medical conditions and their treatments on driving performance have been published. Using the PubMed inventory of the National Library of Medicine, we searched the medical literature for the period June 1995 through March 2004, using the search terms “driving impairment,” “vision and driving,” “cardiovascular and driving,” “diabetes and driving,” “sleep and driving,” “respiratory and driving,” “musculoskeletal and driving,” “seizure and driving and epilepsy,” “dementia and driving,” “stroke and driving,” “brain injury and driving,” and “mental illness and driving.” These search terms identified 3,196 article titles. Relevant abstracts were read online and 90 full-text articles were retrieved and read, along with 11 additional articles known to the authors. Of these, [XX] articles were considered to have information pertinent to the medical review of drivers and are cited in this edition of the *Physician's Guide*.

The secondary purpose for revising the *Physician's Guide* was to clarify the criteria for evaluating drivers and to make the criteria more consistent across medical conditions that have different medical manifestations but similar effects on driving. For example, we tried to indicate clearly which drivers do not need to be followed in the driver medical evaluation program. The simplest way to do this was to replace the term “Standard” interval for review with the term “None,” indicating that the driver must renew his or her license at the same interval as any other driver who is not followed in the driver medical evaluation program. We also attempted to clarify that drivers who demonstrate control over their illnesses for increasing periods of time may be discharged from the driver medical evaluation program, with no further need for follow-up. We made these periods of control consistent across disease categories, so that drivers with seizure disorders and depression whose illnesses are under control need not be followed longer in the driver medical evaluation program than drivers with diabetes. Finally, we clarified that drivers with substance abuse disorders are followed by the hearing officer program and not by the driver medical evaluation program. We hope these changes will make it easier for physicians, patients, and patient advocates to understand what is expected of drivers with medical impairments to driving.

About the Authors of the Second Edition

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PART I. THE DRIVER MEDICAL EVALUATION PROGRAM

Purpose of the Guide

This guide is written for physicians. It lists criteria for evaluating people who have medical conditions that could affect driving performance. Physicians can use the guide to counsel their patients about driving or to understand how licensing decisions are made on the basis of medical evidence of risk for crash and injury.

Although the guide is written for physicians, others might find it useful as well. Attorneys, judges, law enforcement officers, and groups that represent people who are concerned about drunk driving policies and practices (such as Mothers Against Drunk Driving), people with chronic illnesses (such as the North Carolina Affiliate of the American Diabetes Association), people with disabilities (such as the North Carolina Head Injury Foundation), and older adults (such as the American Association of Retired Persons), among others, can refer to this guide for information about specific medical conditions and evaluation criteria.

To establish these guidelines, the authors have reviewed published research, government documents, and guidelines from the American Medical Association¹ and other states. Scientific evidence was used to set criteria for licensing restrictions and reevaluation schedules. However, for some medical conditions that affect driving, there is insufficient scientific research to establish criteria on the basis of crash risk. For these conditions, medical judgment was relied upon to set criteria.

To understand this guide, the reader will need some knowledge of medicine and injury control. However, medical slang is avoided, and medical terms are used only when standard English is not precise enough to convey the intended meaning. People who have no medical training should be able to interpret most of the criteria with the aid of a dictionary.

Traffic Safety

Injury is the third leading cause of death, after heart disease and cancer. Most injury deaths result from motor vehicle injuries. In fact, motor vehicle injury is the number one cause of death for children, adolescents, and young adults.

Medical impairments including alcoholism account for about half of all crashes resulting in serious injury or death.³ Consequently, states have assumed the responsibility of restricting or revoking driver licenses on the basis of medical impairments to driving (reference 1). A study of the Utah driver medical evaluation program found that drivers with certain medical conditions had elevated crash risks (Vernon 2002). Realizing that traffic safety depends on safe driving performance, the North Carolina driver medical evaluation program was established to ensure that persons licensed to drive in our state are medically qualified to operate a motor vehicle safely.

Driving is a privilege that is valued by all North Carolina drivers, and no less so by those who are ill or injured. For persons with illnesses and injuries that have resulted in functional impairments, a driver license can make it possible to work, to be self-reliant, and to be a productive member of society.⁵ However, the driving privilege should not be granted at the expense of traffic safety.

Prevention of Disabilities

A driver license symbolizes autonomy, independence, mobility, employability, public trust, and self-esteem. A person who is denied the privilege of driving for medical reasons is, by definition, disabled.⁶ Therefore, every effort should be made to enable a person to drive safely for as long as possible, provided that the safety of the motoring public, as well as the safety of the driver, is protected.

Consider the hypothetical case of a 17-year-old boy newly diagnosed with diabetes mellitus.⁵ In terms used by authorities in the field of disability prevention, the underlying pathology is diabetes, the impairment is hypoglycemia and resulting loss of consciousness, the functional limitation is inability to operate a motor vehicle, and the disability is loss of licensure.⁶ If asked by the Division of Motor Vehicles to evaluate this case, the Medical Advisor would attempt to determine whether the boy's diabetes is under control. If not, the Medical Advisor would probably recommend that the boy and his physician work to prevent further hypoglycemia episodes, whereupon a recommendation could be made to the Commissioner of Motor Vehicles to have his license restored. In this example, the driver medical evaluation program has succeeded in promoting safe driving and minimizing disability.

In other cases, the Medical Advisor may seek assistance not only from the driver's personal physician but also from other experts who may be able to provide important information to assess or improve driving performance. These experts may be medical specialists or allied health care workers, such as neurologists, physiatrists (should this be psychiatrists?), psychologists, physical therapists, assistive technologists, and others. The Medical Advisor may request a road test from a Driver License Examiner for the same purpose. These additional evaluations are requested so that people can be assisted whenever possible to manage their limitations and drive safely.

History of the Driver Medical Evaluation Program

Medical impairments may increase both crash risk and the risk of injuries resulting from crashes. In an effort to reduce highway morbidity and mortality, the North Carolina Medical Society, in 1964, in conjunction with the Division of Motor Vehicles (DMV), established a program to evaluate drivers suspected of being medically impaired. The general guidelines and administrative policies concerning the licensure of impaired drivers were developed at that time by the North Carolina Medical Society's Committee on Traffic Safety. The Traffic Safety Committee also recruited physicians to serve on medical consultant panels to review cases.

In 1968, the responsibility for making medical recommendations was shifted from DMV to the Division of Health Services. A set of guidelines was published in 1978 (reference 2). A physician was hired by the Division of Health Services to be the Medical Advisor to DMV and to manage the Driver Medical Evaluation (DME) program. In [YEAR?], this program was moved to the Medical Review Branch, Driver License Section, Division of Motor Vehicles, in the North Carolina Department of Transportation. The driver medical evaluation program evaluates

only a small proportion of drivers. Many people with medical impairments restrict their own driving without referral to this program. In these situations, family members and physicians can often provide good advice.

Identification of Impaired Drivers

Any individual reasonably suspected of having a physical or mental impairment that may adversely affect his or her ability to safely operate a motor vehicle is required to submit a completed DMV Medical Report from a physician and/or a Visual Examination by an ophthalmologist or optometrist. DMV also has the right to request follow-up reexaminations to determine whether the driver's medical condition is under control.

Individuals may be brought to the attention of the driver medical evaluation system in several ways. At the time of initial licensing or at renewal of the driver license, drivers with medical conditions may be detected when they answer questions about seizures, diabetes, alcohol-related problems, or other medical conditions. Driver license examiners and police officers may also report individuals who appear ill or disabled; in fact, in-person license renewal is associated with a lower fatal crash rate among drivers ages 85 years and older (Grabowski 2004). Drivers' medical problems may also be reported by physicians, concerned family members, or neighbors. Reports from the courts of adjudications of incompetence or involuntary commitments for the treatment of alcoholism or drug addiction will also prompt a medical evaluation. Finally, cases may also be referred by the Division of Services to the Blind.

Physician Referrals

Some states authorize physicians to refer their patients for driver medical evaluation without threat of legal action for breaching physician-patient confidentiality, and some states even require physicians to refer patients with certain medical conditions, such as abrupt loss of consciousness or dementia, that could impair safe driving performance.^{8,9} In North Carolina, physicians are not required to refer their patients for driver medical evaluation. However, North Carolina physicians may perhaps be confronted with a legal as well as an ethical dilemma if they have expert knowledge of a patient's medical condition that may be hazardous for driving. While no North Carolina physician has yet been convicted of a criminal offense or successfully sued for failing to report a medically unfit driver, case law in other states has supported an obligation to refer medically unfit drivers for evaluation.^{12,13,14}

Evaluation Procedure

After the driver has been examined by his or her regular physician (or optometrist, if no problem other than visual acuity is suspected), and the required evaluation forms have been submitted to the Medical Branch of the Driver Licensing Section, Division of Motor Vehicles, all pertinent information is assembled and reviewed by physicians known as Medical Advisors. Pertinent information may include the Driver License Section Special and Reexamination Report, the driving record, Accident Reports, and past medical information in the case of a reexamination.

The Medical Advisor may request additional information including summaries of hospital admissions, consultations by specialists, and information from the courts.

After reviewing all relevant information, the Medical Advisor recommends whether a license, with or without restrictions, should be issued. The Commissioner of Motor Vehicles, exercising his or her discretion and considering any other factors bearing on public safety, makes the final decision to grant, revoke, or restrict a driver license. Medical Advisor recommendations may take the form of:

- 1) Approval without restrictions or follow-up;
- 2) Approval with restrictions: of speed (45 MPH), roadway type (no interstate driving), distance from home (for example, only within a 10-mile radius of home), hours or days of operation (for example, daylight driving only; weekdays between 6AM and 6PM only), only with the use of corrective lenses or of assistive or operating devices necessary for safe operation of the vehicle (for example, power steering, power brakes, automatic transmission, hand controls, outside mirror, seat cushion), or other restrictions (for example, only to and from work);
- 3) Disapproval for a specific or indefinite time; or
- 4) Permanent disapproval.

Appeals

Any licensure restriction or denial may be appealed, provided a written request is filed with the Division of Motor Vehicles within ten days of receipt of such denial. Appeals are heard by the Medical Review Board, which consists of the Commissioner or his authorized representative and two State-licensed physicians from a panel appointed by the Chairman of the Commission for Health Services. If an appeal is requested within the ten-day time limit, the license cancellation is rescinded and a hearing date is scheduled.

At the hearing, the petitioner's driving and medical records are reviewed, and the petitioner may also present any other pertinent information, including testimony by witnesses, affidavits from members of the medical profession, and additional documents in support of his or her case. The petitioner may also be represented by legal counsel. After hearing all the evidence, the Medical Review Board has the authority to affirm or rescind the Commissioner's decision. If the decision is adverse to the driver, he or she may appeal the Board's decision in Superior Court.

The Hearing Officer Program

A driver who has had his or her license revoked as a consequence of having two convictions for Driving While Impaired (DWI) within a three-year period may petition to have the license conditionally restored. Currently, all evaluations for the purpose of restoring driving privileges revoked for DWI violations are conducted by the Hearing Officer Program. In these hearings, the driving record, a substance abuse evaluation, and testimony of the petitioner and his witnesses are examined. This is a DMV procedure that does not involve the Medical Advisor.

If the driving privilege is restored, restrictions of daylight driving and Class C License

only, along with a probation agreement, are imposed for a specified period of time. Installation of an ignition interlock may also be required for the driver's vehicle. Of course, the driver may choose not to have a hearing, in which case his or her license will be restored automatically after four years as long as there are no further DWI convictions.

The Science of Injury Control

The purpose of the North Carolina driver medical evaluation program is to reduce morbidity and mortality from motor vehicle injuries that result from medically impaired driving. Programs such as this one that focus on human behavior (in this case, driving) are based upon the rapidly developing science of injury control.

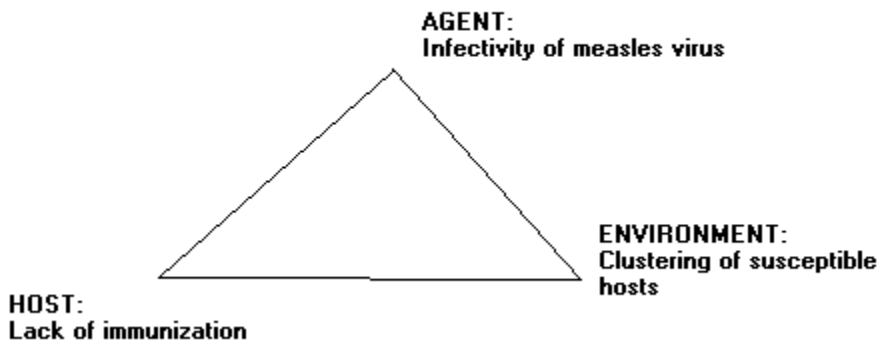
William Haddon, Jr., the first administrator of the National Highway Traffic Safety Administration, developed ten strategies¹⁵ for injury control:

1. Prevent the creation of the hazard.
2. Reduce the amount of the hazard.
3. Prevent the release of the hazard.
4. Modify the rate or spatial distribution of release of the hazard from its source.
5. Separate, in time or space, the hazard and that which is to be protected.
6. Separate the hazard with a barrier.
7. Modify relevant basic qualities of the hazard.
8. Increase resistance to damage.
9. Begin to counter the damage.
10. Stabilize, repair, and rehabilitate.

Driver medical evaluation is intended to prevent driving hazards (Strategy #1) by ensuring, for example, that licensed drivers remain seizure-free and have correctable vision. Each of these 10 strategies has advantages and disadvantages. Strategies near the top of the list, such as preventing the creation of the hazard, are likely to be most effective, but also are likely to be least acceptable to people who rely on some benefit provided by the hazardous product or activity. Moreover, some of the strategies in the list may be unavailable for certain hazards. An overall plan for injury control that emphasizes as many of these strategies as possible is likely to be more effective than a plan that relies on only one or two strategies. The strategies listed above apply mainly to hazardous products, such as cars, but Haddon further developed his theory of injury control to include strategies to modify the environment (the road, for example) and human behavior (such as driving). This theory is similar to a model of disease control (Figure

1) used to conceptualize efforts to prevent the spread of communicable diseases. By stretching the disease control model to arrange host factors, agent factors, and environmental factors along one axis, and adding a second axis (Figure 2) that categorizes control methods according to their timing in relation to the injury event, Haddon was able to show that injury control is more than picking a method from a list. Injury control is a multifaceted approach that acts at different times and places on products and people. This conceptual model, known as the Haddon matrix, can be applied to all types of injuries. Empty cells in the model indicate that new ideas for controlling injuries may be needed.

Figure 1. Examples of factors that influence the control of communicable diseases.



The Haddon matrix incorporates driver medical evaluation into the pre-event host cell. Crash reports have been used to estimate the potential impact of driver medical evaluation on the reduction of injury morbidity and mortality. These studies have estimated that human error, medical impairment (such as dementia), or some other driver factor is responsible for 64 to 71 percent of all crashes.¹⁶

Figure 2. Examples of factors that influence the severity of motor vehicle crash injuries, by the period of their greatest influence in relation to the crash (adapted from Haddon).

	Host	Agent	Environment
Pre-Crash	dementia	blowout	signs
Crash	seat belts	airbags	breakaway poles
Post-Crash	bleeding	entrapment	trauma system

Of course, advances that would fit into other cells of the matrix could influence driver medical evaluation as well. For example, modifications to vehicles and roads may enable drivers with certain existing impairments to drive safely.¹⁹ Vehicle modifications may include hand controls and ignition interlock devices, and road modifications may include markings and signs with better visibility. In the words of Patricia F. Waller, PhD, who made major contributions to driver safety at the University of North Carolina Highway Safety Research Center and the University of Michigan Transportation Research Institute, "The idea that the highway transportation system is a given and that drivers must adapt to whatever it is must be reconsidered... the highway transportation system must take into account the characteristics of the real-world driving population, not be designed for a hypothetical ideal." (Ref 19.)

The Older Driver

In general, drivers over the age of 65 years drive fewer miles per year than younger drivers. By reducing their exposure to driving, older drivers reduce their opportunity for crashes. However, when crash rates for drivers in different age groups are compared by the number of miles driven per year, those at the youngest and oldest ends of the age continuum have the highest crash rates.

The impact of age-related medical impairment is likely to increase over time, because the U.S. population is gradually aging. It has been estimated that by the year 2030, 21 percent of the U.S. population will be age 65 years or older,²⁰ as compared to 12.4% in 2000 (www.census.gov, viewed on 7/20/04).

However, it is difficult to predict the proportion of the *driving* population that will be made up of older adults in future years. Some older adults restrict their driving miles and even discontinue driving for medical and other reasons at the suggestion of physicians or family members.²¹ Furthermore, older drivers as a group appear to be healthier and better drivers than they have been in the past.²⁰ It is likely that older adults who choose to drive will drive even more safely in the future.

Some older drivers do drive poorly.²² Older drivers are often not as adept at coping with complex traffic situations.²³ They are also more likely to be charged with failure to stop, failure to yield, and safe movement violations. When drivers are compared by age alone, the 65- to-69-year-old age group is twice as likely to initiate a crash as the 45- to49-year-old age group. Thereafter, the risk increases with age.²⁴

However, driver age is not directly responsible for increased crash risk. Instead, age should be considered a marker of increased risk for medical problems that impair driving.²⁵ Almost all medical problems occur more frequently in older people, and medical problems may affect driving before they become so severe that drivers seek medical attention. For this reason, some states require drivers to be evaluated more frequently as they age.^{26,27} These requirements are not intended to make licensing decisions solely on the basis of age, but they are intended to screen older drivers more frequently to find out whether they have medical problems that warrant driving restrictions. However, a recent study (Grabowski 2004) found that a more frequent driver

license renewal period for older drivers was not associated with a reduced crash fatality rate. On the other hand, this same study (Grabowski 2004) found that states requiring in-person license renewals did have lower crash fatality rates among drivers older than 85 years, presumably because in-person license renewal allows driver license examiners to observe subtle signs of medical impairment in drivers and refer them for driver medical evaluation. Clearly, crash rates for older drivers do not justify a policy of licensure solely on the basis of age, because age-related impairment is variable,²⁹ but a policy of in-person license renewal, at least for the oldest drivers, combined with a system of driver medical evaluation for certain drivers suspected by driver license examiners, physicians, or others of having medical impairments to driving, appears to reduce the risk of crashes and crash-related injuries. Medical evaluation and licensing decisions should continue to be made on a case-by-case basis, regardless of age, and the driver and the physician should explore treatment solutions that will enable all people who wish to drive to be able to drive safely for as long as possible.

PART II. GUIDELINES FOR PHYSICIANS

Legal Responsibility and Functional Status

In North Carolina, drivers are required to demonstrate the mental and physical ability to drive safely.³⁰ The Division of Motor Vehicles may require written tests, oral tests, road tests, vision tests, or medical examinations to assess the driver's ability, but the burden of proving the ability to drive rests with the driver. Furthermore, driving ability does not depend on the presence or absence of a particular medical condition but is determined on the basis of whether a person with the medical condition can operate a motor vehicle safely.

Therefore, the guidelines that follow are categorized by the driver's functional status.^{31,32,33} In other words, wherever possible, driving restrictions are based on the driver's ability to manage his or her medical condition (by taking medications as directed, for example), to adapt to a functional impairment (by learning to use prostheses), or to compensate for loss of function (by learning to use new driving techniques), as well as the driver's underlying medical condition.

For each medical condition or grouping of conditions, there are four broad categories of functional status.³⁴ These categories are: 1) No known impairment; 2) Past impairment, fully recovered or compensated; 3) Active impairment; and 4) Condition under investigation. Driving restrictions are determined on the basis of a driver's functional status within one of these four categories.

Restrictions and Follow-up Evaluations

Regardless of the underlying medical condition, there are eight basic types of driving restriction: 1) daylight driving only; 2) no driving on interstate highways; 3) speed restrictions; 4) distance restrictions; 5) destination restrictions (to and from the grocery store, for example); 6)

class of vehicle restrictions; 7) vehicle modification restrictions; and 8) medical appliance restrictions, such as for prostheses or eyeglasses. In addition, special restrictions are sometimes applied to enable drivers with unusual conditions to be permitted to drive safely.

The duration and frequency of follow-up evaluations is dictated by the clinical course and predicted response to therapy and therefore may vary by type of medical condition. For example, medical conditions that are lifelong and slowly progressive may require infrequent medical assessments for many years, whereas drivers who have self-limited or curable conditions (such as post-traumatic seizures or cataracts) should be removed from the driver medical evaluation program altogether.

There are also practical considerations. It may be appropriate and even desirable for drivers with medical conditions that are likely to respond quickly to changes in therapy, such as seizure disorders and diabetes mellitus, to have very frequent (six-month) evaluations. Unfortunately, driver medical evaluation is a complex and time-consuming process, and six-month evaluations are not always feasible.

Principles of Evaluation

In general, restrictions and follow-up periods are based on these guiding principles:

1. Need for restrictions: Restrictions are applicable to medical conditions that interfere with safe driving. Therefore, restrictions recommended by the Medical Advisor are indicated only for medical conditions that could interfere with driving performance and that may occur while the affected individual is driving. (Note that driving restrictions may also be applied by driver license examiners based upon their observations during the road test. For example, the driver license examiner may require a driver with a right foot deformity to use automatic transmission or a left-sided accelerator.)

2. Phases of the driving task: Functional driving impairments include the ability to gather information about vehicle and road conditions (for example, visual information), the ability to process information and make appropriate decisions (for example, when and how to cross a busy intersection), and the ability to act on those decisions (for example, the strength to depress a brake pedal). Global deficits, such as a loss of consciousness, may affect all three phases. Of the three, the most difficult to assess and predict is the ability to process information and make appropriate decisions. Consequently, restrictions may often have to be tailored to the driver's specific needs.

3. Other medical conditions: A driver may have more than one medical condition. Two or more conditions may result in functional impairments requiring restrictions in more than one category. Clinical judgment on the part of the examining physician and the Medical Advisor may determine the need for restrictions or follow-up evaluations that do not conform strictly to our guidelines.

4. Sources of information: The driver's entire record should be used to determine the need for driving restrictions. This includes the Medical Report Form; the driving record; crash

reports; performance on road, sign, and written tests; occupational therapy driver evaluations; consultations with specialists; and any previous reports, letters, or statements in the driver medical evaluation file. If written expert opinions conflict, issues may be resolved by direct communication with the driver's physician, or the Medical Advisor may use his or her best medical judgment to resolve them. Inconsistencies in information provided by the driver may also be taken into account. Major emphasis will be placed on the report of a physician who has had the opportunity to examine the driver and who has had a longstanding therapeutic relationship with the driver.

5. Consequences of driver impairment: Unless otherwise noted, these guidelines apply to drivers of passenger (Class C) vehicles such as cars, pickup trucks, and small vans. Drivers of heavy vehicles and school buses may be held to stricter medical standards because errors by drivers of these vehicles would be more likely to result in injuries to larger [?] numbers of people.

Introduction to the Guidelines

The following sections on medical conditions that may affect driving are arranged in the order in which they appear in the Medical Report Form. A brief summary of the epidemiologic evidence linking the medical condition to crashes and injuries is followed by a set of guidelines for determining restrictions and the frequency of follow-up evaluations.

VISUAL DISORDERS

Most of the relevant information for driving reaches the motor vehicle operator by vision. Good vision is necessary for safe driving. Fortunately, standard visual criteria for driving are well accepted by the medical community and are fairly well supported by driver safety studies. Reevaluation is often necessary because many eye diseases are progressive (diabetic retinopathy, macular degeneration³⁵) or correctable (cataracts (Owsley JAMA ref)).

Monocular vision

Drivers with good visual acuity (corrected or uncorrected) and no loss of visual fields in one eye may drive safely, even if blind in the other eye.³⁶ Their driving performance is similar to that of drivers with binocular vision.³⁷ However, suddenly occurring monocular vision is more incapacitating than monocular vision that has been present long enough for the driver to become accustomed to it.³⁸ For this reason, drivers who must have a temporary dressing placed over one eye should not drive until they are comfortable with monocular vision. Realistically, temporary patching is not a medical condition that is likely to come to the attention of the driver medical evaluation program, and therefore decisions about driving should be discussed by patients and their physicians.

Visual acuity

Although routine vision testing for all drivers may not be associated with reduced fatality rates (Grabowski 2004), drivers with poor visual acuity cannot drive safely unless their visual acuity is correctable. Visual acuity criteria are based in part on the visibility of traffic signs. To meet standards of the U.S. Department of Transportation, freeway traffic signs are lettered in such a way that they are visible to a driver with 20/40 visual acuity moving at authorized maximum speeds and under normal weather conditions.¹ In North Carolina, drivers with vision correctable to 20/70 are restricted to non-freeway speeds (a maximum of 45 miles per hour) and to non-interstate roadways.

Central visual acuity should be assessed without the use of telescopic lenses, because they obstruct and reduce the size of the visual fields of the wearer.^{1,40} The effect is similar to scanning the horizon with a telescope; the driver can see very little of it at a time. Much of the traffic pattern, such as adjacent lanes, parked cars, and merging vehicles, may consequently be invisible. Therefore, telescopic lenses are unacceptable for meeting the visual acuity requirements for driving. If a driver qualifies visually but wishes to wear a telescopic lens in addition to standard corrective lenses, the telescopic lens should be prescribed by a licensed ophthalmologist or optometrist. The visual specialist will be able to ensure that the driver can look around the telescopic lens and view the full traffic pattern.

Dynamic visual acuity is the perception of objects when there is relative motion of the object and the observer.⁴¹ Dynamic visual acuity tests have been advocated as being more comparable than static tests to real driving situations. However, these tests have not been found to predict crash risk any better than static tests,^{41,42} and they are not generally available or

practical for most visual examinations.³²

Color Vision

Red-green color discrimination is not necessary for driving, because the position of colored traffic signals has been standardized,³² and yellow and blue color have been added to red and green traffic signals, respectively, to enhance color perception.¹ However, the completely color blind individual usually has poor central visual acuity and may also have visual field loss.

Night Vision

It is important for night drivers to be able to see well because the proportion of crashes that result in fatalities is much greater at night.⁴³ Night vision has three components: central acuity under reduced illumination, glare tolerance, and glare recovery time, as expressed in seconds necessary to regain satisfactory night vision after exposure to disabling glare.¹ Unfortunately, economical and reliable night vision testing procedures are not generally available, and results are often not reproducible.⁴⁴

The physician testing for adequate night vision must instead look for structural alterations of the eye that are associated with impaired night vision, such as corneal opacities, cataracts, macular degeneration,(Scilley2002, Szlyk 1995) optic atrophy, or retinopathy.¹ Treatment of glaucoma with pilocarpine produces miosis (constricted pupil) and myopia (nearsightedness) in young people and may consequently impair night vision as well.

Visual acuity decreases as background illumination decreases, and it decreases with advancing age even at high levels of background illumination.⁴² For example, older drivers may have to be 25 to 35 percent closer to road signs to be able to correctly identify the orientation of the letter "E."⁴² Table 1 illustrates how difficult it can be for older drivers to see well at night.

Table 1. The Percentage of a Group of 91 Older Drivers Who Passed a 20/40 Visual Acuity Test, by Background Luminance and Age Group*

<u>Luminance</u>	<u>Age Group</u>		
	<u>60-64 years</u>	<u>65-74 years</u>	<u>≥ 75 years</u>
Full illumination (245.5 cd/m ²)	100	96	89
Night driving, urban roads (2.45 cd/m ²)	77	28	4
Night driving, urban roads (.78 cd/m ²)	0	0	0

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The luminances indicated to be characteristic of night driving in this table are about twice as bright as could be expected in actual night driving situations.⁴² Therefore, the percentage of older drivers who can see well at night may be even lower than this table suggests.

Contrast Sensitivity

Contrast sensitivity is the ability to detect differences in luminance between adjacent areas, such as a light-colored, reflective oncoming vehicle approaching from the East on a sunny morning, or a dark-colored oncoming vehicle emerging from a tunnel at dusk. Drivers with cataract who have impaired contrast sensitivity are more likely to crash than drivers without contrast sensitivity impairment (Owsley Arch Ophth 2001). Fortunately, drivers with cataract often reduce their own driving exposure (Owsley J Geront 1999). One study has reported that patients with cataract may reduce their crash risk by having cataract surgery with intraocular lens implantation (Owsley, 2002). However, it has been pointed out that cataract surgery appears to result in a reduction of only about 5 crashes per million miles driven (Klein 2002). If the driving privilege has been denied because of visual impairment resulting from cataract, it makes sense to re-evaluate driving performance after cataract surgery.

Visual fields

Decreased peripheral vision is associated with crashes at intersections.⁴⁵ These crashes usually occur on the side of the driver's greatest visual field loss. Most states require drivers to have 140° fields of vision.⁴ A study of drivers with visual fields greater than 160° and drivers with visual fields of 140° or less found both groups to have similar crash rates,⁴⁶ but this study did not look specifically at drivers with very narrow visual fields. Studies of drivers with moderate to severe visual field loss in both eyes have found that these drivers have twice the crash risk of drivers without visual field loss.^{36,47}

Currently, North Carolina requires only a visual field of 60° in one eye, or 30° on each side of the central point of fixation, for drivers of personal or private vehicles that are not for hire (Class C). Therefore, a driver may lose much of his or her field of vision without losing the driving privilege. One form of severe bilateral field loss is homonymous hemianopsia, which is usually caused by stroke. (Gilhotra 2002) Persons with left-sided hemianopsia cannot see out of the left side of either eye, and persons with right-sided hemianopsia cannot see out of the right side of either eye. These persons are much more severely impaired than monocular drivers, who can see both sides of the traffic pattern. Persons with homonymous hemianopsia are consequently prohibited from driving.

The Goldmann 30 cm radius bowl perimeter has become the reference standard for testing visual fields since its introduction in 1945.¹ However, less cumbersome and less expensive equipment may be used. For example, visual fields can be assessed by means of confrontation testing with eye-to-eye fixation. The examiner measures awareness of a moving finger at the periphery and compares it with his or her own visual fields, which must be normal. Both confrontation testing and perimeter testing provide useful information to the Medical Advisor, and therefore the results of both types of testing should be provided.

The following requirements must be met for peripheral field testing:

1. Peripheral field testing should be done without correction. Tangent screens are not acceptable. Reports must include a copy of the visual field chart denoting the type and size of the target with the test distance.

2. On a standard perimeter, a white 3mm test object at 330mm with illumination of not less than 7 foot-candles should be used. On an aphakic eye, a 6mm object should be used.
3. On a Goldmann type perimeter, II4 or III4 settings should be used for a phakic eye and IV4 for an aphakic eye.
4. Automated peripheral field testing instruments are acceptable if settings comparable to the Goldmann perimeter are used, and if testing includes temporal field to 60 degrees and nasal field to 60 degrees.

Diplopia

A driver who develops diplopia soon learns to ignore one of the images (White 2001) or close one eye to suppress it. However, drivers with acute diplopia who have not learned to do this may be advised to patch one eye or refrain from driving until they are comfortable with monocular vision. Persistent diplopia is rare and may be caused by neurologic diseases such as multiple sclerosis, supranuclear gaze palsies, and conditions affecting the extraocular muscles. Diplopia warrants case-by-case review to assess its likely effect on driving performance.

Useful field of view

A person may be able to pass a visual acuity test and a peripheral vision test in the doctor's office and still be unable to interpret and act promptly on visual information while driving. The driving environment is rich with visual stimuli. From this environment the driver must use search and pattern recognition skills to select and act upon relevant visual information.⁴⁸ The visual field area over which information can be acquired during a brief glance is the "useful field of view."⁴⁹ It is typically smaller than visual field size as measured by perimetry. Older drivers with a 40% or greater impairment in the useful field of view have been shown to have twice the crash risk of older drivers with normal useful fields of view; this increased crash risk was primarily attributable to difficulty in dividing attention under brief target durations (Owsley 1998).

Components of the useful field of view test (reduced speed of visual information processing, inability to ignore distractions, or inability to divide attention) are cognitive rather than purely visual disturbances, but they are mentioned here to point out that the driving record is as important as the Medical Report for evaluating a driver's ability to receive and act on visual information. In driving environments that are particularly rich with visual information, such as intersections, drivers with restrictions of the useful field of view may have difficulty avoiding crashes. Consequently, a driving record in which intersection crashes appear to have occurred with increasing frequency may indicate the need for driving restrictions despite a "normal" visual examination.

DRIVER IMPAIRMENT PROFILE: VISUAL DISORDERS

Functional Status	Condition Example	Driving Restrictions*	Interval for Review*
No known impairment	Visual acuity 20/40 or better without correction	None	None†
Past impairment, fully recovered/compensated	Vision correctable to 20/50 or better	Corrective lenses‡	None
Active impairment			
a. Potential interference with driving	Vision correctable to 20/50 or better, but could deteriorate soon as a result of progressive disease	Corrective lenses	1-2 years
b. Interferes with driving	(1) Vision correctable to 20/70	Corrective lenses, 45 mile per hour speed limit, no driving on interstate highways	1 year
	(2) Vision correctable to 20/100	Corrective lenses, 45 mile per hour speed limit, no driving on interstate highways, daylight driving only	6-12 months
	(3) Vision not correctable to 20/100	No driving	...
c. Permanent interference with driving	Vision not correctable to 20/100; no chance of recovery	No driving	...
Condition under investigation	Newly reported change in visual acuity	Variable	As needed

*These driving restrictions and intervals for review are only guidelines; individual restrictions and intervals for review are at the discretion of the Medical Advisor.

†The standard interval for vision testing is at driver license renewal (every five (**check this**) years). These patients do not need to be followed in the driver medical evaluation program.

‡Corrective lenses are required only if they improve visual acuity. Telescopic lenses are unacceptable for meeting the visual acuity requirements for driving.

HEART DISEASE

The risk of crash and injury associated with heart disease is not directly related to the type of heart disease (for example, congenital heart disease, atherosclerotic heart disease, or myocarditis). Instead, crash risk is most directly related to the effect of the underlying illness on a person's functional ability to operate a motor vehicle. For example, a driver who has had one or more myocardial infarctions but who has no dyspnea, angina, or excessive fatigue with ordinary physical activity (Cardiac Functional Class I) does not need to be followed in the driver medical evaluation program. On the other hand, a driver with Class III or Class IV cardiovascular impairment is not permitted to drive, because ordinary physical activity may result in fatigue, dyspnea, or pain. Similarly, persons with cardiac rhythm disturbances may drive only if they are free of syncope.

Syncope

Most of the increased risk of crash injury for people with heart disease is related to loss of consciousness. Recurrent loss of consciousness as a manifestation of heart disease (syncope) is related to failure of the cardiac muscle to pump adequate blood to the brain. Recurrent syncope is a common problem accounting for up to six percent of all hospital admissions and three percent of all emergency department visits annually in the U.S.⁵⁰ Syncope may result from heart failure, or from disturbances in cardiac rhythm such as tachycardia or vasovagally mediated (Blitzer 2003) hypotension and bradycardia. Recurrent syncope may respond to drug therapy or pacemaker implantation.(Blitzer 2003,⁵⁰

About 4 percent of survivors of ventricular tachycardia or ventricular fibrillation will have an event such as recurrent ventricular fibrillation, syncope, implantable fibrillator discharge, or hemodynamically unstable ventricular tachycardia in the first month after hospital discharge.⁵¹ This rate decreases to 1.8 percent per month in months 2 through 7 and decreases further to 0.6 percent per month in months 8 through 12. However, a subgroup of patients has a persistently high rate of cardiac events (1.6 percent per month) even beyond seven months, despite drug therapy. A recent study (Akiyama 2001) of 627 drivers with near-fatal ventricular tachyarrhythmia who resumed driving after drug or defibrillator treatment found no association of duration of abstinence from driving and arrhythmia-related motor vehicle crash and concluded that drivers should be allowed to drive immediately after antiarrhythmic treatment; however, over half the drivers in this study had not resumed driving, on the advice of their physicians, for at least 6 months after their near-fatal episode. Therefore, drivers at greatest risk of arrhythmia-related motor vehicle crash may not have been driving during the period of greatest risk, and it is difficult to conclude from this study that these patients are safe to drive immediately after starting antiarrhythmia treatment. Taking all available scientific evidence into consideration, it is prudent to recommend that all persons should be free of syncopal episodes for at least six months to be granted the driving privilege, and specifically that persons who have had an episode of ventricular fibrillation or ventricular tachycardia should be free of these events for at least six months before resuming driving.^{51,52,53} By analogy, it also seems logical to require persons who have had cardiac bypass surgery, coronary angioplasty, or myocardial infarction to be free of syncope for at least six months before resuming driving.

In addition to syncope, loss of consciousness may occur as a manifestation of sudden death. However, sudden death accounts for fewer than six of every 10,000 motor vehicle crashes,⁵⁴ and it is difficult to predict because it often occurs without previous signs or symptoms of heart disease.⁵⁵

Therefore, drivers with heart disease are not routinely followed or restricted unless they are at risk for recurrent loss of consciousness, or unless they have marked impairment of cardiac function.

Cardiac Function

The Medical Advisor may recommend restrictions or revocation of the driving privilege for drivers with severe impairment of cardiac function. These recommendations are based on standard functional criteria (Table 2). In addition, some cardiovascular medications, such as anti-hypertensive drugs, may cause vertigo, lightheadedness, loss of consciousness, or a change in mental status. Drivers with these side effects are advised not to drive while taking these medications.

Heart disease is so common that it often accompanies other medical conditions affecting traffic safety. The coexistence of heart disease and other conditions may act together to increase crash risk,⁵⁶ and therefore driving restrictions may be warranted even if they would not be required for an individual with only one of the coexisting medical conditions.

Table 2: Classification of cardiovascular impairment*

<u>Class I:</u>	The patient has cardiac disease but no resulting limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, dyspnea, or anginal pain.
<u>Class II:</u>	The patient has cardiac disease resulting in slight limitation of physical activity. The patient is comfortable at rest and in the performance of ordinary, light, daily activities. Greater than ordinary physical activity, such as heavy physical exertion, results in fatigue, palpitation, dyspnea, or anginal pain.
<u>Class III:</u>	The patient has cardiac disease resulting in marked limitation of physical activity. The patient is comfortable at rest. Ordinary physical activity results in fatigue, palpitation, dyspnea, or anginal pain.
<u>Class IV:</u>	The patient has cardiac disease resulting in the inability to carry out any physical activity without discomfort. Symptoms of inadequate cardiac output, pulmonary congestion, systemic congestion, or the anginal syndrome may be present, even at rest. If any physical activity is undertaken, discomfort is increased.

*Adapted from the functional classification of the American Heart Association and the New York Heart Association (American Medical Association. Medical Conditions Affecting Drivers. Doege TC, Engelberg AL, eds., 1986.).

DRIVER IMPAIRMENT PROFILE: HEART DISEASE

Functional Status	Condition Example	Driving Restrictions*	Interval for Review*
No known impairment	No known disorder	None	None†
Past impairment, fully recovered/compensated	AHA Class I without syncope or dysrhythmia	None	None
Active impairment			
a. Potential interference with driving	(1) AHA Class II or dysrhythmia‡ controlled on medication without syncope for at least 6 months	None	2-4 years depending on driving record and presence of co-morbid conditions
	(2) Dysrhythmia symptomatic on medication but without syncope for 6 months; cardiac pacemaker or cardioverter-defibrillator without syncope for 6 months	None	1 year
b. Interferes with driving	AHA Class III, unstable dysrhythmia, or recurrent syncope	No driving	...
c. Permanent interference with driving	AHA Class IV, uncontrolled dysrhythmia, or recurrent syncope	No driving	...
Condition under investigation	New onset of symptoms or signs of heart disease	Variable	As needed

*These driving restrictions and intervals for review are only guidelines; individual restrictions and intervals for review are at the discretion of the Medical Advisor.

†These patients do not need to be followed in the driver medical evaluation program.

‡Persons with recurrent ventricular tachycardia or fibrillation must have a cardiac pacemaker or cardioverter-defibrillator to be able to drive safely, unless pharmacotherapy has been completely successful in preventing recurrences of ventricular fibrillation, syncope, or hemodynamically unstable ventricular tachycardia.

DIABETES MELLITUS AND OTHER ENDOCRINE DISORDERS

Most drivers with diabetes are probably no more likely to crash than drivers without diabetes. Some studies have found that diabetic drivers overall have 30 to 80 percent more crashes than the general driving population^{22,57} and that they are more than twice as likely to have a crash resulting in injury.⁵⁸ However, much of this increased risk is probably accounted for by drivers in poor diabetic control. Most drivers with diabetes mellitus probably have a crash risk that is similar to the crash risk of the general driving population, perhaps because of self-regulation by those in declining health,⁵⁹ while a subset of diabetic drivers have a much greater crash risk. For example, a group of 1,441 patients with diabetes enrolled in a clinical trial and followed closely for a mean of 6.5 years⁶⁰ had only 0.29 crashes and 0.3 traffic fatalities per 100 patient years,⁶¹ but patients were carefully selected for this study based on disease characteristics and on their understanding of study objectives and procedures,⁶⁰ and in the real world, some persons with diabetes are not likely to be as compliant with therapy. The task of driver medical evaluation is to identify diabetic drivers in poor control and recommend driving restrictions until they can resume control of their illness.

For most illnesses that affect driving, treatment reduces the risk of a crash. Insulin-dependent diabetes is different. The more tightly that blood sugar is controlled with insulin treatment, the more likely it is that the driver will take too much insulin or too little food and have an episode of hypoglycemia. Hypoglycemia that is severe enough to cause unconsciousness can lead to a crash, but even moderate levels of hypoglycemia can result in subtle cognitive changes when the driver appears to be asymptomatic.^{57,62,63} These subtle changes can affect the performance of complex driving tasks affecting visual information processing (McCrimmon 1996), judgment,⁶⁴ steering,⁶⁵ and speed. Furthermore, disrupted driving performance during moderate hypoglycemia is often not recognized by the affected driver.^{64,65} Diabetic drivers with good glycemic control are at increased risk⁶² for developing cognitive impairment before the onset of adrenergic symptoms such as palpitations, tremor, and nervousness that persons with diabetes rely upon to warn them of hypoglycemia.

North Carolina's guidelines are based on the frequency and timing of untreated hypoglycemic episodes that result in a decreased level of consciousness or altered mental status. This is analogous to the way that drivers with seizure disorders or syncope are evaluated. A recent episode of altered consciousness, whether it is due to hypoglycemia, a seizure, or syncope, indicates that the underlying illness is not well controlled and that the risk of a crash may be elevated. If the hypoglycemic episode is related to a transient, self-limited condition, such as a viral illness, and the driver's diabetes is otherwise well controlled, the Medical Advisor may recommend an unrestricted license.

Recent research indicates that mild hypoglycemia may result from the increased metabolic demands and stress of the driving task (Cox 2002). Although some drivers may be able to drive well enough with hypoglycemia that they do not crash even if they cannot recall the drive (Weinger 1999), driving with hypoglycemia is clearly dangerous. Some researchers recommend testing blood glucose before driving and keeping fast-acting glucose readily available (for example,

clipped to the visor) so that finding it is not an additional delay to self-treatment (Cox 2000). Drivers with occasional hypoglycemic episodes who treat their hypoglycemia promptly with readily available glucose and do not have impaired driving do not need to be followed in the driver medical evaluation program. However, drivers with hypoglycemic episodes who are unaware of their hypoglycemia (Clarke 1999), who do not treat their hypoglycemia promptly with glucose (Cox 2000), or who receive traffic citations as a result of impaired driving should be followed in the driver medical evaluation program and restricted as indicated in the Driver Impairment Profile.

Diabetic Complications and Other Endocrine Disorders

Functional criteria for evaluating drivers with complications of diabetes mellitus such as heart disease, blindness, and peripheral neuropathy are discussed in other sections of this Guide. Endocrine disorders other than diabetes are also evaluated in terms of functional impairment. For example, drivers who have hypoglycemic episodes resulting from pituitary insufficiency or adrenal insufficiency are evaluated much the same as drivers who have hypoglycemic episodes resulting from diabetes mellitus. Drivers with visual field defects resulting from pituitary tumors are evaluated according to the degree and type of visual impairment.

Drivers with syncope due to inadequately managed adrenal insufficiency are evaluated as having sudden, reversible loss of consciousness. The same principles used to evaluate drivers with syncope resulting from primary cardiovascular disorders apply to drivers with syncope resulting from endocrine disorders. Parathyroid disorders may lead to muscular weakness, muscle spasms, or alterations of consciousness. Again, medical evaluation will depend upon the nature of the functional impairment. Finally, the multisystem effects of thyrotoxicosis and severe hypothyroidism may preclude safe driving.

**DRIVER IMPAIRMENT PROFILE: DIABETES MELLITUS
AND OTHER ENDOCRINE DISORDERS**

Functional Status	Condition Example	Driving Restrictions*	Interval for Review*
No known impairment	No known disorder	None	None†
Past impairment, fully recovered/compensated	History of endocrine disorder, such as gestational diabetes, or active endocrine disorder, under control, without hypoglycemia, loss of consciousness, or altered mental status for at least 1 year	None	None
Active impairment			
a. Potential interference with driving	Active endocrine disorder, under control, without hypoglycemia, loss of consciousness, or altered mental status for at least 6 months	None	Re-evaluation after 6 additional months of control
b. Interferes with driving	Active endocrine disorder, inadequately controlled for driving purposes, with 1 or more episodes of untreated hypoglycemia, loss of consciousness, or altered mental status in the past 6 months	No driving	Re-evaluation after 6 months of control
c. Permanent interference with driving	Uncontrollable endocrine disorder with frequent hypoglycemia, loss of consciousness, or altered mental status	No driving	...
Condition under investigation	Newly discovered endocrinopathy	Variable	As needed

*These driving restrictions and intervals for review are only guidelines; individual restrictions and intervals for review are at the recommendation of the Medical Advisor. Complications of diabetes mellitus and other endocrine disorders, such as peripheral neuropathy, are evaluated according to functional criteria for the appropriate physiologic system (such as musculoskeletal or visual disorders).

†These patients do not need to be followed in the driver medical evaluation program.

RESPIRATORY DISORDERS AND SLEEP DISORDERS

With the exception of sleep apnea, crash risks for persons with respiratory disorders have not been determined. However, by analogy, persons with severe hypoxemia are likely to be medically impaired, because a lack of oxygen can result in altered mental status or loss of consciousness.

Hypoxemia

For the purpose of driving, severe hypoxemia is defined as a $paO_2 < 60$ mmHg, or a $pO_2 < 60$. Some persons can achieve oxygen levels greater than this by using supplemental oxygen while driving. However, oxygen-dependent drivers must be able to demonstrate in a road test that they can simultaneously manage their respiratory equipment and operate a motor vehicle safely.

Hypercarbia

A more insidious consequence of respiratory disease is hypercarbia, which may produce symptoms of dizziness, lethargy, and poor attentiveness. Hypercarbia ($pCO_2 > 50$ in room air) is a high level of carbon dioxide in the lungs resulting from an inability to ventilate adequately. Measurement of pCO_2 is generally not recommended by the Medical Advisor, because the reliability and validity of this test often depend on test conditions and on intermittent attacks of certain respiratory illness, such as asthma. Therefore, the pCO_2 test is not as likely as the pO_2 or paO_2 to reflect the driver's usual condition of respiratory health.

Sleep disorders

Falling asleep at the wheel may account for one to 13 percent of crashes in the United States each year (Lyznicki 1998,⁶⁷ As many as 30 to 40 million people in the U.S. may have narcolepsy, obstructive sleep apnea, or chronic insomnia. Drivers with sleep-related disorders, including narcolepsy and sleep apnea, are involved in 1.5 to 4 times as many sleep-related crashes as the general population (ref 67).

Narcolepsy, a disorder involving daytime sleepiness and sleep attacks, is commonly associated with cataplexy and sleep paralysis.⁶⁸ Sleep attacks may be triggered by monotonous activities such as driving. In fact, 60 to 80 percent of narcoleptic patients have fallen asleep while driving, at work, or both.⁶⁹ Treatment regimens include the encouragement of naps to improve daytime alertness and pharmacotherapy.

Obstructive sleep apnea is a disorder in which the upper airway collapses repetitively during sleep.⁷⁰ These repetitive collapses result in nocturnal hypoxemia and severely deranged sleep, and patients with sleep apnea are consequently inattentive and sleepy during daylight hours. It has been estimated⁷¹ that the proportion of middle-aged adults who have both sleep-disordered breathing and self-reported hypersomnolence is two percent among women and four percent among men. Drivers with sleep apnea may have delayed reaction times and difficulty maintaining concentration.⁷⁰ When tested on driving simulators, they often fall asleep.

It is not surprising that drivers with sleep apnea are more likely than normal drivers to be involved in crashes. One study⁷² found that drivers with sleep apnea were seven times as likely to crash as drivers without sleep apnea. Treatment with nasal continuous positive airway pressure (CPAP) (reference 73) has been shown to improve driving performance (70, George 1997) and reduce crash risk (George 2001).

Excessive daytime sleepiness is a common feature of Parkinson disease, even in the absence of dementia, although sudden-onset sleep without warning may be infrequent (Hobson 2002). Though some studies have attributed sleepiness to the drugs used to treat Parkinson disease (Hauser 2000), sleepiness appears to result instead from sleep fragmentation due to disordered breathing, nighttime motor disability, dysuria, depression, periodic leg movements during sleep, and REM sleep behavior disorder, all of which are features of Parkinson disease (Hobson 2002, Comella 2002). The Epworth Sleepiness Scale and the Inappropriate Sleep Composite Score may be useful for identifying Parkinson disease patients likely to fall asleep while driving.

DRIVER IMPAIRMENT PROFILE: RESPIRATORY AND SLEEP DISORDERS

Functional Status	Condition Example	Driving Restrictions*	Interval for Review*
No known impairment	No known disorder	None	None†
Past impairment, fully recovered/compensated	Respiratory symptoms or signs resulting from pulmonary, metabolic, cardiovascular, or other underlying illness, fully recovered	None	None
Active impairment			
a. Potential interference with driving	Respiratory illness with episodic dyspnea, controlled with medication, without loss of consciousness or alteration of mental status sufficient to impair driving in at least 6 months; or sleep disorder without an episode of falling asleep at the wheel and losing control of the vehicle for at least 6 months	None	None
b. Interferes with driving	50 < pO ₂ < 60 at rest on room air, pO ₂ > 60 with supplemental oxygen	May drive if supplemental oxygen‡ is used at all times while driving to raise pO ₂ > 60	1 year
c. Permanent interference with driving	pO ₂ < 50 on room air or pO ₂ < 60 with supplemental oxygen; or sleep disorder unresponsive to treatment	No driving	...
Condition under investigation	Newly discovered respiratory or sleep disorder	Variable	As needed

*These driving restrictions and intervals for review are only guidelines; individual restrictions and intervals for review are at the recommendation of the Medical Advisor.

†These patients do not need to be followed in the driver medical evaluation program.

‡Oxygen-dependent drivers must be able to demonstrate in a road test that they can simultaneously manage their equipment and operate a motor vehicle safely.

MUSCULOSKELETAL DISORDERS

Very little research has been done to determine crash risk for persons with musculoskeletal problems such as amputated limbs, casts, braces, joint disease, or muscle weakness. However, at least one study⁷⁴ has found that persons with stable disabilities involving the extremities, whether due to amputation, congenital anomalies, trauma, post-polio syndrome, or other conditions, can drive safely with aids such as prostheses, hand controls, or other technical modifications of the vehicle. With these compensations, there does not appear to be an appreciable increase in the rate of crashes. After operative repair of ankle fracture, braking time steadily improves at six, nine, and 12 weeks, with baseline braking time achieved at nine weeks (Egol 2003).

Vehicles equipped with clutches and manual transmissions require that drivers have four functioning extremities.¹ Cars with power steering and automatic transmission are easier to operate for people with decreased muscle strength or range of motion. In general, the advice and participation of an expert in rehabilitation should be obtained when selecting adaptive equipment for the motor vehicle and planning specialized driver's training. People with unstable or progressive musculoskeletal impairment may require rather frequent reevaluation by a neurologist, an orthopedist, a physiatrist, or another medical specialist or specialty team to determine whether new or modified devices should be used or whether the driver's functional ability can no longer permit safe operation of a motor vehicle. Drivers with musculoskeletal problems might also benefit from skill polishing lessons from a certified driving school.

DRIVER IMPAIRMENT PROFILE: MUSCULOSKELETAL DISORDERS

Functional Status	Condition Example	Driving Restrictions*	Interval for Review*
No known impairment	No known disorder	None	None†
Past impairment, fully recovered/compensated	History of non-progressive disorder that currently does not impair driving and does not require special equipment‡	None	None
Active impairment			
a. Potential interference with driving	(1) Active, non-progressive disorder that does not impair driving, provided that appropriate assistive equipment is used	Assistive equipment as directed by the Medical Advisor; speed and distance restrictions may also be necessary to compensate for slowed reaction time or other considerations	2-4 years with road test
	(2) Active, progressive disorder that currently does not impair driving	Assistive equipment as directed by the Medical Advisor; speed and distance restrictions may also be necessary	1-2 years with road test
b. Interferes with driving	Active disorder that impairs driving, despite the use of assistive equipment, but with potential for recovery	No driving	...
c. Permanent interference with driving	Active disorder that impairs driving despite the use of assistive equipment, without potential for recovery	No driving	...
Condition under investigation	Newly discovered musculoskeletal disorder	Variable	As needed

*These driving restrictions and intervals for review are only guidelines; individual restrictions and intervals for review are at the recommendation of the Medical Advisor.

†These patients do not need to be followed in the driver medical evaluation program.

‡ Assistive equipment may include prostheses, hand controls, or other devices

SEIZURE DISORDERS

By the age of 80, ten percent of the population will have a seizure and four percent will be diagnosed with epilepsy.⁷⁵ Sudden, unexpected loss of consciousness is a particularly worrisome problem for drivers. One study (ref 76) reported that persons with seizure disorders have crash rates⁷⁶ that are 1.4 to 2.0 times as high as the general population, adjusting for age and number of miles driven per year. Another study (Taylor 1996) comparing drivers with a history of epilepsy to drivers in the general population, controlling for age, sex, and driving experience (number of years since first driver license), found that crash risk may vary by the seriousness of the crash. There was no difference in crash risk overall, but the study demonstrated a 40 percent increase in crashes producing serious injury and a doubling of crash risk for non-driver fatality. These findings confirm a previous report that seizure patients may have more serious crashes.⁷⁷ Although the proportion of all crashes attributable to epilepsy is 0.3 to 1.0 per 1,000, the number of fatal crashes attributable to epilepsy is 0.1 to 5.0 per 1,000.⁷⁶

Epilepsy

Epilepsy is a chronic, intrinsic cerebral disorder characterized by recurrent seizures.⁷⁵ By definition, one seizure is not sufficient to diagnose epilepsy. For example, a person may have a simple seizure that is not expected to recur as a result of trauma, illness, or medical treatment. Obviously, people with ongoing seizure disorders and people who have had only one seizure have different driving risks. Moreover, many people with epilepsy become seizure-free, either as a result of therapeutic seizure control or remission of the seizure disorder. In North Carolina, driver medical evaluation takes these different risks of seizure recurrence into account. The risk of seizure recurrence for persons with untreated seizure disorders has been estimated to be three to five percent per year for the first two to three years after antiepileptic drug withdrawal, and 0.5 percent thereafter.⁷⁸ In another study,⁷⁵ antiepileptic drugs were withdrawn from patients who had been seizure-free after two years of treatment with a single drug. Thirty-five percent of these patients had a seizure within three years. The remaining patients remained seizure-free for follow-up periods ranging from six to 62 months. More importantly for purposes of driver medical evaluation, the patients in this study, who had to have had at least two seizures in the six months before entering the study and having their antiepileptic drugs withdrawn, relapsed (had a seizure) at a rate of 5.9 percent per month for the first three months, 2.7 percent per month for three to six months, and 0.5 per month for six to nine months. These results illustrate the difficulty in choosing an appropriate seizure-free interval after which persons with epilepsy may resume driving. The probability of seizure recurrence is reduced appreciably at three months and again at six months but remains measurable within the same order of magnitude until a year or more. On the basis of these and other data, various states have chosen to restrict licenses for three-month, six-month, or one-year seizure-free intervals.⁴

There is suggestive evidence that participation in the North Carolina driver medical evaluation program results in a reduced crash rate for persons with seizure disorders. Crash rates were measured for a group of epileptic persons before and after they were enrolled in the driver

medical evaluation program.⁷⁹ Before enrollment, this group had a crash rate that was four times the rate of a control group selected from the general population, adjusting for age, race, and sex. After enrollment in the program, the epileptic group had a crash rate that was 1.7 times the general population rate.

How did enrollment in the driver medical evaluation program result in a 58 percent reduction in the crash rate? Perhaps the drivers with poor seizure control were restricted from driving, giving them less opportunity to lose consciousness and crash. Perhaps instead the crash rate was reduced because drivers who were previously noncompliant with antiepileptic drug therapy were motivated to take their medication as prescribed to keep their driving privileges. Another possibility is that drivers may have left the crash scene or failed to report minor crashes after being placed in the driver medical evaluation program. Obviously, the program has not been completely successful in reducing the crash rate for this group of drivers, since even after enrollment their crash rate was almost twice that of the general population.

Requirements for North Carolina

In North Carolina, drivers are recommended to be seizure-free for six to 12 months. This seizure-free interval is based on the results of the studies mentioned above, with the intention of preventing people from having a seizure while driving.^{75,80} Consequently, persons with seizure disorders may drive if their disorders are well controlled with antiepileptic therapy or if they are in remission. Recognizing that some persons who have had a recent seizure are at less risk of recurrence than others, the following exceptions to this general rule are occasionally allowed: 1) A person who has a seizure because his or her anti-epileptic therapy has been recently changed or withdrawn by a physician may continue to drive if the previous therapy, which controlled the seizure disorder, is immediately resumed; and 2) A person who has rare seizures that occur only while he or she is asleep or whose seizures do not result in loss of consciousness, loss of control of motor function, or loss of appropriate sensation and information processing may continue to drive.

Previously, it was recommended that a driver with seizures preceded by an aura of at least two or three minutes could be allowed to drive, reasoning that the aura would give the driver sufficient warning to allow him or her to pull off the road and stop the car before losing consciousness. However, a study of drivers with epilepsy (Taylor 1996) found that epileptic drivers reporting auras had no better crash risk than epileptic drivers without auras.

Other unusual circumstances may affect the general requirement that drivers be seizure-free for six to 12 months; interpretation of these circumstances and assignment of restrictions is at the discretion of the Medical Advisor. However, compliance with medical therapy is essential for safe driving. If a previously uncontrolled seizure patient becomes suddenly compliant and free of seizures, he or she must still be seizure-free for six to 12 months to establish that a change of behavior (and consequently of functional limitation) has truly occurred.

DRIVER IMPAIRMENT PROFILE: SEIZURE DISORDERS

Functional Status	Condition Examples	Driving Restrictions*	Interval for Review*
No known impairment	No known disorder	None	None†
Past impairment, fully recovered/compensated	History of seizure disorder, now resolved, or active seizure disorder, under control, without loss of consciousness or altered mental status for at least 1 year	None	None
Active impairment			
a. Potential interference with driving	Active seizure disorder, under control, without loss of consciousness, altered mental status, or loss of control of motor function for at least 6 months	None	Re-evaluation after 6 additional months of control
b. Interferes with driving	Active seizure disorder, inadequately controlled for driving purposes, with 1 or more seizures in the past 6 months	No driving	Re-evaluation after 6 months of control‡
c. Permanent interference with driving	Uncontrollable seizure disorder with frequent, recurrent seizures	No driving	...
Condition under investigation	Newly discovered seizure disorder	Variable	As needed

*These driving restrictions and intervals for review are only guidelines; individual restrictions and intervals for review are at the recommendation of the Medical Advisor.

†These patients do not need to be followed in the driver medical evaluation program.

‡At the recommendation of the Medical Advisor, a shorter period of follow-up before the next driver medical evaluation may be sufficient if the driver has had a seizure because his or her antiepileptic therapy has been recently changed or withdrawn by a physician, and if the previous therapy, which controlled the seizure disorder, is immediately resumed.

DISTURBANCES OF HIGHER CORTICAL FUNCTION: DEMENTIA, STROKE, TRAUMATIC BRAIN INJURY, AND MENTAL RETARDATION

The ability to think clearly and react appropriately to changing road conditions is necessary for safe driving. Consequently, driving is one of the many complex activities that can become very difficult as a result of brain damage. The causes of cognitive impairment may be stable or progressive, isolated or global. Predicting the effect of brain damage on driving performance depends on knowing what disease process or type of injury the driver has, the extent of the impairment resulting from it, and the likelihood that this impairment will get worse. Therefore, dementia, stroke, traumatic brain injury, and mental retardation are discussed separately in this chapter, because the pattern of cognitive impairment and the types of evaluations and restrictions required are somewhat different for each of these conditions.

Dementia

Dementia is a chronic, progressive deterioration of memory, intellect, and communicative functioning.⁸¹ It occurs in as many as 15 percent of persons older than 65 years⁸² and 30 percent of persons older than 85 years.⁸³ Dementia is usually a result of Alzheimer disease or multiple infarctions of the brain.

Considering that dementia is progressive, the most appropriate question to ask with respect to driving may not be whether a person with dementia should drive, but how soon they should stop driving.⁸⁴ As cognitive function declines, driving performance also declines (Reger 2004, Stutts 1998). Family members, physicians, or caregivers should initiate this discussion early in the disease process so that planning for the change can take place in a timely manner. Dementia may progress fairly rapidly. Fortunately, people with dementia usually self-restrict or stop driving before action is taken by licensing authorities to restrict or revoke their driver licenses.^{85, Caselli2000} and Foley 2000 and Trobe 1996 and Stutts 1998) Perhaps four percent of persons with dementia continue to drive.^{11,86,87}

Dementia patients who continue to drive may put themselves and others at risk for a crash. One study⁸⁸ found that drivers with Alzheimer dementia were eight times as likely as non-demented drivers to have crashed during the study period. Crashes occurred even at early stages of dementia. With every year of disease duration, crash rates increase (Carr DB). At a Clinical Dementia Rating (CDR) of 0.5 (roughly equivalent to a Mini-Mental State Examination score of 25), characterized by forgetfulness and slight difficulty with time relationships, drivers with Alzheimer dementia may have crash risks similar to drivers ages 16 to 21 years old (Dubinsky 2000). By the time the CDR has reached 1.0 (within a year or two), crash risks are much higher (Dubinsky 2000, Duchek 2003). Some authors have suggested that drivers with CDRs of 0.5 to 1.0 be evaluated every six months until their driving performance deteriorates sufficiently to prohibit them from driving. However, testing drivers with progressive cognitive impairments this frequently is not likely to be feasible in North Carolina or other states (Duchek 2003). A more realistic approach would be to encourage drivers with Alzheimer disease to stop driving as soon as possible after diagnosis, which is apparently what most of them do with advice from their

physicians and families and without the need for evaluation by the driver medical evaluation program.

When evaluating drivers with dementia, it has been suggested¹³ that the following factors be considered: driving at night, in rush hour, or in adverse weather conditions; presence of a front seat passenger to help navigate or take the wheel in an emergency; familiarity with roadways; and whether the driver reports problems with activities of daily living that reflect a decline in several areas of cognitive functioning. Patients with Alzheimer disease may have difficulty perceiving shapes defined by motion cues (Rizzo 1998), among other deficits.

Although Alzheimer disease and cerebrovascular disease are the major causes of dementia, multiple sclerosis (Schultheis 2002) and minimal hepatic encephalopathy (Wein 2004), can also impair cognition and driving performance.

Road tests, occupational therapy driver evaluations, and comprehensive clinical evaluations can help guide licensing decisions. Recently it has also been reported that dementia may be detectable using the sign test given at the time of driver license renewal in North Carolina.¹³ The sign test measures a driver's ability to see, recognize, and interpret signs and their meaning. Using a cut-off point of fewer than nine out of 12 correct answers, drivers with dementia were detected with 100 percent sensitivity and 95 percent specificity, compared with healthy older adult drivers.

Stroke

Drivers with stroke are more likely to be involved in at-fault crashes than the general driving population (McGwin 2000). In contrast to dementia, in which cognitive deficits are global and predictably progressive, stroke often results in major loss of function in specific areas while completely sparing others. Therefore, licensing decisions must be tailored to the driver's particular needs. Furthermore, some function may return within a few months of the stroke and then stabilize. If this stabilization occurs, the Medical Advisor may recommend that driving restrictions be relaxed. However, stroke patients should be re-evaluated periodically regardless of their level of functioning because someone who has had one stroke is at risk for having another. Complicating the picture even further, dementia and stroke may coexist, which should not be surprising since one form of dementia is simply the result of numerous tiny strokes.

Right-sided strokes can result in left-sided hemiplegia or perceptual and cognitive impairment without hemiplegia. Perceptual and cognitive impairment may manifest themselves through reduced awareness of traffic conditions, left-right direction confusion, inadequate use of space, poor planning, and limited ability to shift focus in response to the changing demands of the driving task. In these cases, patients may appear to have recovered completely after a "mild" stroke, only to find that they can't pass a road test. Consequently, persons who have had strokes on the right side of the brain may be more difficult to re-train in specialized driver education programs than persons with left-sided strokes.^{89,90} About eight percent of persons who have had strokes have a homonymous visual field defect,(Gilhotra 2002) which is an absolute contraindication for driving.

Stroke patients may have subtle deficits (of attention, for example) that are not obvious

clinically but become apparent after formal psychometric testing (Marshall 1997). Some tests may be useful for identifying drivers likely to fail on-road driving tests (Mazer 1998, Klavara 2000), and others are less useful (Korner-Bitensky 2000). In the United Kingdom, a battery of three tests administered as the Stroke Drivers Screening Assessment measures deficits in executive abilities, attention, and visuospatial skills (Radford 2004). The Useful Field of View test, which measures processing speed, divided attention, and selective attention, may be useful not only for identifying deficits in stroke patients (Fisk 2002) but in retraining them to improve their skills and perhaps resume driving (Mazer 2001). Taken together, the available evidence suggests that stroke patients may have important cognitive deficits that are not apparent clinically. Some psychometric tests may be sensitive enough to detect deficits and identify poor driving performance. However, driving should probably not be recommended on the basis of good scores on psychometric tests without also giving the driver a road test.

Transient Ischemic Attacks

A transient ischemic attack⁶⁸ is a focal loss of neurologic function caused by interference of blood circulation to the brain (ischemia). Transient ischemic attacks are abrupt in onset, persist for less than 24 hours, and clear without residual signs of impairment. Most last for only a few minutes. Clinicians may use other terms to describe ischemic events that persist longer than 24 hours; for purposes of driver medical evaluation in North Carolina, these are considered "strokes."

Individuals who have had a transient ischemic attack are at increased risk for future stroke. Estimates place the annual stroke risk at five percent per year for the first three years following a transient ischemic attack, decreasing to three percent in subsequent years.⁶⁸ Treatment of transient ischemic attacks (also referred to as "threatened strokes") may include smoking cessation; dietary modification; treatment of underlying causes such as hyperlipidemia, diabetes mellitus, or hypertension; pharmacotherapy with vasoactive drugs such as calcium channel blockers or antithrombotic drugs; and surgery. However, pharmacotherapy and surgery for this condition are controversial. Physicians should be aware that treatment of recurrent transient ischemic attacks may predispose the driver to other conditions with equal or greater potential to impair driving performance.

Traumatic Brain Injury

Impacts to the head or penetrating injuries of the brain may also result in impairments to driving. Cognitive abilities may improve by six months after injury, but further improvement may be expected by 12 months (Novack 2000). Some drivers who have had traumatic brain injury have very mild perceptual-motor and cognitive impairment. In fact, some may have normal ability to receive, process, and act on the information they receive in the course of the driving task. Others report anger, aggression, irritability, memory impairment, difficulty concentrating, or inattention (Hawley 2001).

One way to conceptualize the special problems encountered by many brain-injured drivers is to think of driving as being a strategic, tactical, and operational activity.⁹¹ The strategic

aspects of driving are concerned with planning when and where to drive. Head-injured drivers can make strategic decisions to minimize some of the impairing effects of their injuries. For example, perceptual and psychomotor processes may often take more time after traumatic brain injury (Brouwer 2002). Difficulties with time pressure and divided attention are characteristic of patients who have had diffuse axonal injury as a result of a concussion. Time pressure can often be controlled by the head-injured driver to some extent, by making strategic decisions to drive at times of the day when traffic is less dense and allow greater distances between his vehicle and the vehicle in front of him on the highway. However, other effects of head injury, such as behavioral rigidity and impaired judgment resulting from frontal lobe injury, may interfere with the capacity to make strategic driving decisions (Brouwer 2002).

Tactical decisions, such as adapting speed when entering a residential district, switching on headlights in the rain, and deciding to pass, are made while drivers are actually operating a vehicle in traffic. Problems with impulsivity and poor judgment among head-injured drivers have been observed by investigators at the tactical level of driving performance.^{89,91}

At the operational level, minute-to-minute adjustments are made to changing situations. These include the use of mirrors and controls and of maneuvers to escape danger. Time pressure is likely to be greatest for the head-injured driver at the operational level. Head-injured drivers also often have difficulty performing more than one task at a time (Brouwer 2002), which is commonly called for in driving. At the operational level, driving problems fall into five general categories: inadequate visual screening of traffic and the surrounding environment (Fisk 2002), problems in spatial perception and orientation, poor tracking, slowness in acting,^{92,93} and confusion when more complex actions have to be carried out.

Driving performance after traumatic brain injury is so variable that perhaps no menu of tests, including the driving test, may predict with confidence who can drive safely (Korteling 1996).⁹⁴ Medical evaluation relies not only on testing but on reports from the brain-injured driver's personal physician and the driving record to make decisions about licensure. Research suggests, however, that persons who have had traumatic brain injury will drive better if they can compensate for their deficits by adapting their behavior at higher (strategic or tactical) levels of task performance, such as getting into the correct lane earlier or correcting speed promptly.^{91,93} This emphasis on "anticipatory driving" requires that the brain-injured driver be aware of his or her deficits and their consequences for driving. Therefore, the driver's insight and self-criticism may be even more important to evaluate than the extent of his cognitive deficits. Unfortunately, lack of insight is often a problem for head-injured drivers.⁸ In a study of 35 drivers with severe brain injury who were interviewed at least two years after the injury, none of the 21 who had resumed driving reported seeking reevaluation from the licensing authority despite recommendations from rehabilitation professionals to do so.

Mental Retardation

There is very little published information that is useful for assessing driving impairment associated with deficiencies in intellectual functioning. In North Carolina, when physicians report that their patients have mental retardation, the Medical Advisor asks for psychological testing to

determine as precisely as possible the level of mental function. Information provided by personal physicians and road test performance is also considered in making licensing recommendations.

**Q DRIVER IMPAIRMENT PROFILE:
DISTURBANCE OF HIGHER CORTICAL FUNCTION**

Functional Status	Condition Example	Driving Restrictions*	Interval Review* for
No known impairment	No known disorder	None	None†
Past impairment, fully recovered/compensated	History of dementia of known etiology, fully recovered; or history of stroke or traumatic brain injury without impairment of higher cortical function or sensorimotor function	None	None
Active impairment			
a. Potential interference with driving	History of stroke or traumatic brain injury more than 1 year previously, with residual sensorimotor, cognitive, or other deficits not severe enough to impair safe driving; history of transient ischemic attacks but without attacks for at least 12 months	None	1-5 years; may require road test and/or occupational therapy evaluation
b. Interference with driving	History of stroke or traumatic brain injury more than 1 year previously, with residual sensorimotor, cognitive, or other deficits severe enough to impair safe driving but with potential for improvement with rehabilitation; recurrent transient ischemic attacks with potential for treatment to prevent recurrences	No driving	Re-evaluation after rehabilitation
c. Permanent interference with driving	Impairment of central nervous system function, severe enough to impair driving performance, without potential for improvement;‡ recurrent transient ischemic attacks refractory to treatment; intelligence quotient (IQ) <70	No driving	...
Condition under investigation	Recent stroke or traumatic brain injury (within the past 2 years); active, treatable dementia (such as toxic or infectious encephalopathy)	Variable	As needed

*These driving restrictions and intervals for review are only guidelines; individual restrictions and intervals for review are at the recommendation of the Medical Advisor.

†These patients do not need to be followed in the driver medical evaluation program.

‡By the time a person is diagnosed with a progressive dementia such as Alzheimer disease, he or she is unlikely to be able to drive safely or will become impaired within a few months. For the purpose of driving, this condition is considered "non-treatable" as well as progressive, and therefore the driving privilege may be revoked upon diagnosis, at the recommendation of the Medical Advisor.

MENTAL ILLNESS

Some studies of mental illness and driving risk are difficult to interpret, because they were carried out before accepted diagnostic criteria (such as the Diagnostic and Statistical Manuals⁹⁵) were used to enroll and evaluate study subjects,²² and because drivers were often classified by broad diagnostic categories rather than by functional status. For example, a 1970 study⁹⁶ of crash rates for drivers before and after treatment in a state mental hospital found that those with psychoses and neuroses improved markedly after treatment and even drove better than a group of drivers selected randomly and matched for age, sex, and county of residence. In contrast, drivers with personality disorders continued to have much higher crash rates than the general population of drivers after discharge from the hospital.

In studies of drivers with mental illness and coexisting substance abuse disorders, it can be difficult to determine how much of the crash risk is due to the mental illness and how much is due to the substance abuse disorder.^{96,97,98,99} Antidepressant medication may have a modest beneficial effect in persons with combined depressive and substance-use disorders (Nunes 2004), but it is not a stand-alone treatment, and concurrent therapy for addiction is also indicated.

Psychosis

Psychotic disorders are characterized by an inability to distinguish fantasy from reality.⁹⁸ Psychosis may result from a thought disorder (for example, schizophrenia) or an affective disorder (for example, bipolar or manic-depressive illness). Of these two broad groupings, schizophrenia has not been shown to increase the risk of a crash,⁹⁸ although few studies of schizophrenia and crash risk have been done.^{22,97} However, schizophrenic drivers on psychotropic medication performed poorly on tests of visual perception, attention, and reaction time, irrespective of whether they were taking clozapine or other neuroleptic drugs (Grabe 1999).

Most people with depression are not psychotic. However, depression can be so severe that patients lose contact with reality. One indicator of psychosis is attempted suicide, but even this is not always an indication of psychosis. Many suicide attempts are not intended to be successful, and the ratio of attempted to completed suicide is approximately eight to one.¹⁰⁰ Nevertheless, depressed persons are theoretically at great risk of motor vehicle injury if they are suicidal and have access to a car. In fact, as many as one to two percent of fatal single-vehicle crashes may be suicides.^{1,97} Therefore, people who are severely depressed should not drive. When treatment is successful in reducing the severity of depressive symptoms and signs, it may also result in improved driving performance.¹⁰¹

It can be difficult to separate the effect of mental illness on driving performance from the effects of drug therapy for the illness. However, it appears that drivers in remission for depression may have slowed reaction time as a result of taking lithium.¹⁰² (and Honig 1999) It is not clear how this delay in reaction time affects overall crash risk, but persons who take lithium or other psychoactive drugs may be required to pass a driving test for licensure. Physicians are advised to consider the possible effects of psychoactive drugs on their patients' driving performance, and to counsel their patients accordingly.

Neurosis

People with neuroses may be adversely affected by anxiety or by mental mechanisms they have developed to control their anxiety.⁹⁸ Driving performance for people with neuroses seems to improve with treatment, just as driving performance for people with psychoses improves with treatment.⁹⁷ However, because of the variability of symptoms, it can be difficult to predict the crash risk of neurotic drivers as a group and predict their crash risk. For example, some obsessive individuals are indecisive, whereas others are very safety-conscious.⁸⁹ Driving performance may depend upon the severity as well as the type of mental or emotional symptoms. Marked egocentrism, as seen in some forms of hysteria, may result in rigid driving behavior that is unresponsive to changing road conditions.⁸⁹

Attention Deficit Hyperactivity Disorder (ADHD)

Attention deficit hyperactivity disorder (ADHD) is usually diagnosed in childhood but may persist into adolescence and adulthood. (National Institute of Mental Health, Attention Deficit Hyperactivity Disorder, viewed at www.nimh.nih.gov/publicat/adhd.cfm on June 23, 2004). The classic symptoms of ADHD are inattention, hyperactivity, and impulsivity. However, adults with ADHD may not know that they have this disorder, despite having problems with distractibility, impulsiveness, or restlessness. They may just feel that they have difficulty organizing their time or sticking to a task.

Persons with ADHD have increased crash risks, even after controlling for sex, co-morbid conditions such as depression and anxiety, miles driven, and driving experience, measured as years since first driver license (Woodward 2000, Barkley 2002). However, methylphenidate has been shown to improve the driving performance of ADHD-affected drivers (Cox 2000).

Personality disorder

People with personality disorders are not psychotic, nor are they bothered much by anxiety. Nevertheless, their behavior is often self-centered, impulsive, and aggressive.^{1,103} They may have difficulty accepting authority and object to restrictions placed on their actions. Not surprisingly, they often make poor drivers.⁸⁹ People with personality disorders may have a need to gratify emotional demands, such as anger at restrictions or irrational competitiveness, and this need may take precedence over incentives to perform the driving task. Unfortunately, these disorders often do not respond well to treatment. Persons with personality disorders may continue to crash more often than the general driving population even after treatment.⁹⁶ Not only do they crash more often, but they appear to have an increased risk of death in a crash.¹⁰⁴

DRIVER IMPAIRMENT PROFILE: MENTAL ILLNESS

Functional Status	Condition Example	Driving Restrictions*	Interval for Review*
No known impairment	No known disorder	None	None†
Past impairment, fully recovered/compensated	History of mental illness (excluding substance abuse disorder‡), under control, without indications of risk to self or others for at least 1 year	None	None
Active impairment			
a. Potential interference with driving	Active mental illness under the care of a physician, without indications of risk to self or others for at least 6 months	None	Re-evaluation after 6 additional months of control
b. Interferes with driving	Active mental illness with indications of risk to self or others	No driving	Re-evaluation after 6 months of control
c. Permanent interference with driving	Intractable mental illness with symptoms or behavior that put the driver or others at risk; illness is refractory to medication or other treatments	No driving	...
Condition under investigation	Newly discovered mental illness	Variable	As needed

*These driving restrictions and intervals for review are only guidelines; individual restrictions and intervals for review are at the recommendation of the Medical Advisor.

†These patients do not need to be followed in the driver medical evaluation program.

‡Drivers with substance abuse disorders are followed in the hearing officer program.

USE AND ABUSE OF LEGAL, ILLICIT, AND PRESCRIPTION DRUGS

Substance abuse disorders contribute to more crashes and motor vehicle injuries than any other medical condition.¹⁰⁵ These illnesses may often be unrecognized by drivers or their physicians, and those who need treatment often resist it. Consequently, substance abuse among drivers is a matter for policy makers, law enforcement officers, and the courts, as well as for physicians, substance abuse counselors, and treatment groups.¹⁰⁶ Many drugs can impair driving performance, but the most widely used drug of abuse in the United States is alcohol. In North Carolina, drivers with substance abuse problems manifested by DWI convictions are followed in the Hearing Officer program, and not the driver medical evaluation program.

Alcohol Use and Abuse

Alcohol is a central nervous system depressant that acts initially by releasing the brain from control of thought processes.¹⁰⁷ The first mental processes to be affected are those that depend upon training and previous experience. The finer grades of discrimination, memory, concentration, and insight are dulled and then lost at higher alcohol concentrations. Psychic changes are accompanied by sensory and motor disturbances. As intoxication becomes more advanced, a general impairment of nervous function and a condition of general anesthesia ultimately prevails.

Alcohol is a ubiquitous mind-altering drug. It is estimated that 100 million Americans drink alcohol and that 12 to 15 million are alcoholic.¹⁰⁸ North Carolina's proportionate share of drinkers and alcoholics can be estimated to be 2.5 million and 300,000 to 500,000 persons, respectively.

Binge Drinking and Alcoholism

According to the Behavioral Risk Factor Surveillance System, 2.5 percent of U.S. adults admitted in an anonymous survey that they had operated a motor vehicle "after drinking too much alcohol at least once in the past month."¹⁰⁹ Some of these drinking drivers (about one out of 90 licensed drivers in 1986)¹¹⁰ are arrested and convicted for Driving While Impaired (DWI). Some DWI offenders are chronic heavy drinkers, and others are binge drinkers. Binge drinking, defined as the consumption of five or more drinks on a single occasion (Naimi 2003), generally results in acute impairment and causes a substantial fraction of all alcohol-related deaths. Between 1995 and 2001, the number of binge drinking episodes per person per year increased by 35 percent. Almost three-fourths of binge drinkers were moderate, rather than heavy, drinkers, and binge drinkers were 14 times more likely to drive while impaired by alcohol than non-binge drinkers. Although some binge drinkers have alcoholism, many do not. Some binge drinkers who are arrested for DWI may change their drinking and driving behavior to avoid further conviction, expense, and penalty. However, those who continue to drink and drive are less likely to have control of their drinking, are more likely to be arrested and convicted of DWI, and are more likely to injure themselves or others.

The National Council on Alcoholism and Drug Dependency and the American Medical Society on Addiction Medicine have defined alcoholism¹¹¹ as a primary, chronic disease with genetic, psychosocial, and environmental factors influencing its development and manifestations. The disease is often progressive and fatal. It is characterized by impaired control over drinking, preoccupation with the drug alcohol, use of alcohol despite adverse consequences, and distortions in thinking, most notably denial.

Alcohol and Injury

In 2002, there were over 14,000 alcohol-related crashes (www.hsrrc.unc.edu/pubinfo/2002crashstatistics.htm, viewed on July 7, 2004) in North Carolina, resulting in 11,695 nonfatal injuries and 371 deaths. About one fourth of all fatal crashes are alcoholrelated. While many of these crashes involve drinking drivers who do not have the medical illness of alcoholism, there is little doubt that alcoholism is a greater threat to highway safety than all other medical conditions combined.¹⁰⁵

DWI Arrests and Alcoholism

An arrest or conviction for DWI does not guarantee that the driver has a drinking problem; however, most DWI offenders do have a drinking problem. A group of 67 DWI offenders in Michigan was ordered to have psychiatric interviews before sentencing.¹²² Of this group, 57 percent were alcoholic, 15 percent were said to be "probably alcoholic" because there was inadequate information to make a diagnosis of alcoholism, 6 percent were "prealcoholic or problem drinkers," and 22 percent were non-alcoholic. Therefore, 78 percent of DWI offenders in this study had "pathologically serious drinking problems." Furthermore, all of the drivers in this study with previous DWI convictions were determined to be either alcoholic or probably alcoholic.

Another DWI study¹²³ that was restricted to first offenders found that 54 percent were frequent or heavy drinkers. Frequent drinking was defined as consuming at least twice a week a minimum of five quarts of beer, two pints of liquor, or a fifth of wine per drinking session. In addition, a frequent drinker was defined to have had behaviors such as blackouts, drinking on awakening, drinking at work, missing meals, or drinking for more than six hours at a time. Heavy drinking was defined using consumption and behavioral criteria of even greater severity than these. By the definitions used in this study, over half of first offenders were probably problem drinkers. Still another study found that 64 percent of DWI arrestees were problem drinkers.¹²⁴

Taken together, these studies suggest that half or more drivers arrested for DWI may have a drinking problem. It should not be surprising, therefore, that an arrest for DWI substantially increases the risk of eventual death in an alcohol-related crash.¹¹⁰ This medical risk justifies the requirement in North Carolina that all drivers with arrests for DWI be evaluated for alcoholism by certified substance abuse counselors.

Alcohol Testing and the Diagnosis of Alcoholism

Alcohol concentrations are commonly used to diagnose impairment. They have also been used for the diagnosis of alcoholism.¹²⁵ The National Council on Alcoholism has suggested that a clinical guide for the absolute diagnosis of alcohol dependence is an alcohol concentration $>.15$ without gross evidence of intoxication.¹²⁶ It can be argued that many people would not be able to operate a motor vehicle at all with an alcohol concentration of $>.15$, and that anyone who can operate a motor vehicle has enough tolerance for alcohol to be considered alcohol-dependent.

A study of drivers who were responsible for fatal crashes¹¹³ determined that 86 percent of drivers with alcohol concentrations $>.14$ were alcoholic, but this study did not address whether all arrestees with alcohol concentrations $>.14$ or only those responsible for fatal crashes were likely to be alcohol-dependent. Another study¹²⁷ found a similar proportion of DWI offenders to have substance abuse or dependence disorders, but this proportion was not greater when the offender's alcohol concentration was $>.14$. Summarizing the available evidence, it appears that drivers with alcohol concentration $>.15$ are very likely to be addicted to alcohol, but that not all drivers with alcohol concentration in this range are addicted.¹²⁸

Diagnostic Information in the Driving Record

Alcohol impairment is the only medical condition affecting driving for which we have a

diagnostic test that is routinely performed on the driver at the time he or she is driving. If the test result is .08 or greater, the driver is legally impaired. In other words, a drunk driver with an alcohol concentration that exceeds the legal limit cannot contend that he or she was driving but was not impaired. Alcohol concentrations obtained at arrest appear in the driving record.

However, drivers with alcohol concentrations less than the legal limit may still be impaired. In fact, impairment appears to be dose-related, even at alcohol concentrations far less than .08. Under North Carolina law, a driver may be convicted of DWI even if his or her alcohol concentration is less than .08 if other signs of impairment, such as erratic driving or abnormal performance on psychomotor testing, are observed by the arresting officer.

Not only does alcohol increase the probability of crash involvement at low concentrations,³¹ but it also appears to increase the likelihood of crash initiation (Table 3).

Table 3. The odds of crash initiation for drivers at different alcohol concentrations.*

<u>Alcohol Concentration</u>	<u>Odds Ratio</u>
.00	1.00
.01 - .049	3.26
.05 - .099	4.24
.10 - .145	10.01
...	...
> .25	36.24

*Perneger T, Smith GS. Am J Epidemiol 1991; 134:1138-45. Reprinted by permission.

From this table, it appears that the odds of crash initiation increase exponentially with increasing alcohol concentration, beginning at concentrations lower than .05.

Driving and Prescription Drugs

An assessment¹³³ of the risk of using antihistamines, benzodiazepines, neuroleptics, or narcotics while driving found that users of these drugs were about as likely to crash as the general driving population. Most other studies of the influence of prescription and non-prescription drugs on driving performance have been confounded by the presence of alcohol.^{134,135}

However, the use of benzodiazepines, antihistamines, barbiturates, and narcotics may affect driving performance. Because of their widespread use and detrimental effect on driving performance, benzodiazepines are the most important class of prescription drugs with respect to traffic safety.¹³⁶ Benzodiazepine drugs impair performance shortly after ingestion, and this effect

persists through several days of therapy. Impairment is dose-related.¹³⁷ For some drug-dose combinations, the impairment is comparable to alcohol impairment at a concentration of .08.¹³⁸ Benzodiazepines with shorter half-lives are recommended for geriatric practice, because they are less likely to accumulate in the body and produce side effects such as sedation. However, short-acting benzodiazepines are not guaranteed to be free of sedating effects, particularly if recommended dosing schedules are not adjusted for the slower metabolism and smaller volume of drug distribution in older adults.^{138,139} In fact, at least one short-acting drug, lorazepam, severely impairs driving performance.¹³⁵ Ethanol enhances the binding of benzodiazepines to central nervous system binding sites,¹⁴⁰ resulting in increased sedation.

Drivers under treatment with cyclic antidepressants are about twice as likely to be involved in injury crashes^{137,141} and the risk of crash involvement probably increases with medication dose. The adverse effects of cyclic antidepressants on driving are probably due to sedation¹³⁶ and therefore may be independent of the adverse effects of depression (for which these drugs are commonly prescribed). Physicians should consider beginning antidepressant treatment with small doses and limiting driving until patients can become tolerant to the sedating effects of these drugs.

First-generation antihistamines (diphenhydramine, triprolidine, terfenadine, dexchlorpheniramine, chlorpheniramine, clemastine) can cause sedation and impaired coordination. Some second-generation antihistamines, such as acrivastine and emadastine, also appear to impair driving. However, other second-generation antihistamines, such as loratidine and cetirizine, may not affect driving performance, provided that they are taken at recommended doses without alcohol (Verster 2003). Third-generation antihistamines (fexofenadine, levocetirizine) do not appear to impair driving performance. As more non-sedating second- and third-generation antihistamines become available over-the-counter, drivers may begin to rely less on sedating antihistamine drugs to relieve their allergic symptoms.

Barbiturate drugs are highly sedating and can impair driving performance.¹³⁸ Codeine and other opiate derivatives can impair driving performance, particularly when taken by non-tolerant individuals to alleviate acute pain or cough.^{136,141} Another danger is symptomatic drug withdrawal by tolerant individuals. However, people on methadone maintenance do not appear to have worse driving records or psychomotor skills than healthy, non-addicted drivers.¹³⁶

Other drugs that have effects on the central nervous system may also impair driving, but more research is needed to confirm this finding.^{138,139} It does appear that psychoactive drugs need not be sedating to impair driving performance. For example, lithium can slow reaction time.¹⁰² Physicians and their patients should be aware that there are many combinations of drugs that can have unexpected and dangerous effects on driving performance.¹³⁷

In summary, it is clear that not only medical conditions but also the drugs prescribed to treat them may have important adverse effects on driving. Therefore, the Medical Advisor must take drug therapies as well as illnesses into consideration when making recommendations for driving. Physicians should always counsel their patients about driving risks when they prescribe medications. This advice is most needed when a patient has just been prescribed a new drug with unfamiliar side effects. Patients may also be unaware of a drug's interaction with alcohol. Physicians can help to keep their patients safe by taking their driving needs into consideration when prescribing drug classes, doses, and schedules.

Driving and Illicit Drugs

Driving under the influence of marijuana may be widespread.¹³⁶ In the laboratory, marijuana adversely affects perception, coordination, braking time and other motor skills, mood, and judgment (ref 14). In recent years, the potency of marijuana has increased markedly (Ashton 2001, Compton in JAMA), thereby increasing the level of intoxication for drivers using marijuana.

Less is known about driving hazards associated with the use of other illicit drugs,¹³⁶ but any drugs taken for the purpose of altering mood, perception, or judgment could be expected to be hazardous for driving. For example, methylenedioxymethamphetamine (MDMA, or “ecstasy”), a stimulant with empathogenic mood-altering properties, and gamma hydroxybutyrate (GHB), a central nervous system depressant, may adversely affect driving to the extent that users may fail field sobriety tests (Logan 2001, Couper 2000).

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APPENDIX TO THE FIRST EDITION

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