6. Medical Literature Review

This section reviews the medical literature that addresses the relationship between operator medical conditions, incapacitation and accidents. For many medical conditions, there is either inconclusive or inconsistent data on the direct relationship between accidents and that condition. Any condition that causes sudden incapacitation may result in an accident. The literature appears to support a direct causal relationship between sleep disorders, certain medications, and hypoglycemia and the increased risk of incapacitation that could result in an accident. There is also a relationship between the risk of impairment or sudden incapacitation and poorly controlled or end stage medical conditions. Articles focusing on the natural progression of diseases that may lead to impairment are beyond the scope of this review.

The first six subsections are organized by organ system. The literature search did not identify any relevant articles for hearing loss. The literature on syncope, sleep disorders and attention deficit disorders are each reviewed separately. The final three subsections cover medications, health care provider knowledge and risks posed by the presence of multiple medical conditions. Appendix C contains the abstracts for the articles supporting the information in each subsection along with a glossary of relevant medical terminology. The references cited in this section are summarized in Appendix C. While the search for relevant literature focused on all modes of transportation, the majority of available research focuses on automobile drivers and commercial motor vehicle operators. Some literature is available from the aviation community, but there is no literature for railroad environments.

6.1 Blood Pressure

High blood pressure (hypertension) is very common and correlates with an increased risk of developing additional cardiovascular diseases. The Joint National Committee on Prevention, Detection and Evaluation and Treatment of High Blood Pressure reports that hypertension affects approximately 50 million individuals in the U.S. and approximately 1 billion people worldwide (Chobanian, 2003). Chobanian further reports that anti-hypertensive therapy has been associated with a 35 to 40 percent reduction in the incidence of strokes, a 20 to 25 reduction in myocardial infarction and more than a 50 percent reduction in heart failure. The medical literature substantiates that adequate treatment decreases the risk of heart attack, stroke and congestive heart failure.

A cohort study of over 10,000 men found that elevated blood pressure in young adult men is significantly related to increased long-term CHD, CVD and all cause mortality (Miura et al., 2001). The direct relationship between hypertension and accidents has not been well-addressed in the medical literature.

6.2 Diabetes

People with type 1 diabetes are at risk for hypoglycemia (low blood sugar) which can result in impaired driving performance and sudden incapacitation. Cox et al. (2000) conducted a simulator study that found driving to be significantly impaired during hypoglycemia. Although the literature is not conclusive, diabetics appear to have an increased risk of accidents compared to non-diabetic populations. Several studies, each with different driver populations, have led to

this conclusion (Cox et al., 2003; Dionne, Desjarding, Laberge-Nadeau, and Maaz, 1995; Hansotia and Broste, 1991; Koepsell et al., 1994; Laberge-Nadeau, Dionne, Ekoe and Hamet, 2000; Yslander, 1966). The Dionne et al. (1995) and Laberge-Nadeau et al. (2000) studies examined truck drivers, Koepsell et al. (1994) focused on drivers 65 years or older, and the other three studies did not limit the type of driver. The Hansotia and Broste study (1991) addressed both diabetes and epilepsy. They found slightly increased risk of traffic accidents for drivers affected by either condition.

While many diabetics are aware when they are hypoglycemic and take appropriate action, there are also many that have hypoglycemic unawareness. In a study conducted by Weinger (1999), a significant number of diabetic drivers were unable to recognize that they were impaired. Clarke, Cox, Gonder-Frederick and Kovatchev (1999) found that people with type 1 diabetes may not judge correctly when their blood glucose level is too low to permit safe driving and may continue to drive beyond where it would be safe.

6.3 Hepatic (Liver)

The single study identified and reviewed was insufficient to determine the risk of impairment from hepatic disease. A simulator study conducted by Srivastava et al. (1994) found no deficiencies in the driving performance of patients with cirrhosis and abnormal neuropsychological test results when compared to patients with cirrhosis and normal neuropsychological test results.

6.4 Cardiac (Heart)

The American Heart Association's 2003 Statistical Fact Sheet reports that one in five American males has cardiovascular disease, with coronary heart disease the leading cause of death. Data on general aviation accidents indicates that approximately three accidents per 1,000 (15 per 1,000 fatal accidents) result from the incapacitation of the pilot from all causes (Booze, 1987). Coronary heart disease is the most important cause of sudden incapacitation or death among diseases likely to be diagnosed in general aviation accidents.

Studies show that arrhythmias and ischemia can occur while driving and are associated with accidents (Antecol and Roberts, 1990; Christian, 1988; Halinen and Jaussi, 1994) and that individuals with heart disease are at higher risk of accidents (hansotia and Broste, 1991). However, these accidents are uncommon and tend to be have minor consequences (Christian, 1988; Ostrom and Eriksson, 1987). Drivers with chronic stable heart disease were found to have an increase in heart rate and ventricular arrhythnias as well as ischemia upon driving into a speed trap (Cocco and Iselin, 1992). Drivers age 60 and over with unstable angina are advised by Wielgosz and Azad (1993) to wait one month before resuming driving.

While arrhythmias are the immediate cause of cardiac syncope, coronary heart disease is usually the underlying cause. Ventricular fibrillation and ventricular tachycardia are life-threatening causes of syncope. While supraventicular tachycardia is rarely life-threatening, it can be a significant cause of syncope. Among patients with supraventricular tachycardia, Dhala et al. (1995) found that while syncope can occur and result in impairment in driving ability, voluntary restriction of driving is uncommon. These researchers point out that the best predictor of future syncope is a history of syncope.

There is not a consensus of opinion regarding return to driving after receiving an implantable defibrillator. Some studies suggest that drivers with implantable defibrillators should not be restricted from early return to driving (Akiyama, Powell, Mitchell, Ehlert and Baessler, 2001). Others have indicated that individuals who have this device are still at risk of syncope and death (Kou, 1991). Bansch et al. (1998) reported that 54 percent of individuals had recurrent ventricular tachycardia/ventricular fibrillation and 15 percent had syncopy after implantation of a defibrillator.

Results from the Framingham Heart Study (Cupples, Gagnon and Kannell, 1992) suggest that short-term vulnerability to sudden cardiac death is determined more by intrinsic cardiac factors than by predisposing risk factors. In the long term, overall cardiac risk factors are more important.

Most of the relevant research focuses on private drivers. But even the low risk seen in this population may be unacceptable for locomotive engineers. Drivers who experience a cardiac event while driving have adequate warning and can pull off the road. This would not be an option for a locomotive engineer in control of a train.

6.5 Vision

Decreased visual acuity and decreased visual fields are associated with an increased risk of accidents. In aviation studies, airmen who were monocular, amblyopic or had an aphakic lens implant had higher accident rates than did the total airmen population (Dille and Booze, 1983). Ivers and Mitchell (1999) drew similar conclusions using self-reported data for automobile accidents. Those who have had refractive surgery have higher accident rates, but the difference is not statistically significant and refractive surgery is not identified as a causal factor (Nakagawara, Montgomery and Wood, 2002). Ophthalmic devices, such as corrective lenses or lens implants used by pilots have contributed to aviation accidents and incidents (Nakagawara, Montgomery and Wood, 2001). Nakagawara, Montgomery and Wood (1993) recommend that aphakia pilots applying for either a class 1 or class 2 certificate be considered on a case by case basis while third class pilots may be certified. A study of the effects of age and compromised vision on driving-related skills and on-road accidents found that the older groups had poorer driving-related skills than the younger groups, but no significantly higher on-road accident rates. Statistical analyses showed that compromised vision and visual field loss predicted real-world accidents in the study population (Szlyk, Seiple and Viana, 1995).

6.6 Neurology

A number of studies report an increased risk of accidents in individuals with seizures. One recent U.S. study reported that 55 percent of patients who have seizures while driving have motor vehicle crashes. This same study also observed that patients with intractable seizures often continue driving. Among these drivers, 39 percent had a seizure at the wheel and 27 percent crashed because of a seizure (Krauss, Ampaw and Krumholz, 2001). Factors that significantly decrease the risk of patients with epilepsy having motor vehicle crashes due to seizures are long seizure-free intervals, reliable auras, few prior non-seizure related accidents and not having had their antiepileptic drugs reduced or switched (Krauss et al., 1999). In contrast, Taylor, Chadwick and Johnson (1996) found no overall increased risk of accidents in drivers with a history of epilepsy but there was evidence of an increased risk of more severe accidents in this population.

Other neurological conditions are also associated with increased accident risk. Drivers with cognitive impairment from Alzheimer's and multiple sclerosis (MS) have an increased accident risk (Dubinsky, Stein, and Lyons, 2000; Schultheis, Garay and DeLuca, 2001). Migraine headaches also lead to a higher incidence of motor vehicle crashes. Norton et al. (1997) concluded that migraine may be associated with a 50 percent increase in the risk of a motor vehicle driver injury.

McKiernan and Jonathan (2001) recommend that drivers with vertigo or other disorders which may cause sudden attacks of dizziness should not drive and that commercial motor vehicle operators should have a waiting period absent of symptoms before resuming driving.

Many drivers with head injuries return to driving, including those who report difficulty with behavior, memory, concentration, attention or vision. Few drivers received guidance from their health care provider on driving after the injury. Stroke and Parkinson's disease patients have difficulty with driving tasks and the patients and their families overestimate their ability to drive safely (Heikkila, Purkk and Korpelainen, 1998).

6.7 Non-cardiac Syncope

Non-cardiac factors can also cause syncope. Regardless of the cause, syncope is associated with an increased risk of accidents and the best predictor of future syncope is a history of syncope. The incidence of syncope during driving is unknown, although one study concluded that vasovagal syncope during driving may not be uncommon in patients referred for syncope evaluation (Li, WQeitzel, Easley, Barrington, and Windle, 2000). Individuals with non-cardiac syncope often do not have warning prior to the event (Bhatia et al., 1999).

6.8 Attention Deficit Disorders

Attention deficit disorder (ADD) with or without hyperactivity has been found to be associated with an increased risk of accidents and traffic violations in young adults as well as teenagers (Barkley, Guevremont, Anastopoulos, DuPaul and Shelton, 1993; Barkley, Murphy and Kwasnik, 1996; Jolly and Todd, 1997). Attention deficit hyperactivity disorder (ADHD) patients appeared to perform better in a driving simulator and view themselves as driving better when on medication (Cox, Merkel, Kovatchev and Seward, 2000).

6.9 Sleep Disorders

The literature indicates that there is an increased risk of accidents in individuals with sleep disorders. Although road accidents due to loss of consciousness cause few serious accidents, sudden loss of consciousness from going to sleep is more likely to lead to an accident with fatal trauma than a condition in which the individual has some warning of impending incapacitation (Parsons, 1986).

Stoohs, Guilleminault, Itoi and Dement (1994) conducted a study of 90 commercial long haul truck drivers and found that those with sleep disordered breathing had a two-fold higher accident rate per mile than drivers without sleep disordered breathing. A number of studies have documented the association between sleep disorders and highway accidents. Teran-Santos, Jimenez-Gomes and Cordero-Guevara (1999) found a strong association between sleep apnea, as measured by the apnea-hypopnea index, and the risk of traffic accidents. Shiomi et al. (2002) observed that the automobile accident rate among patients with severe obstructive sleep apnea

was significantly higher than the rate among those who simply snored. In 1998 Barbe et al. reported on a study that compared patients with sleep apnea syndrome (SAS) with a control group. The SAS patients had more accidents than the control group. In addition those in the SAS group were more likely to have had more than one accident. A questionnaire study conducted by Horstmann, Hess, Bassetti, Gugger and Mathis (2000) found that 12.4 percent of the SAS respondents had accidents compared to 2.9 percent for the control group.

Occupational accidents may also result from excessive daytime sleepiness (EDS). Lindberg, Carter, Gislason and Janson (2001) conducted a prospective study to explore this issue. They found that men who reported both snoring and EDS at baseline were at increased risk of an occupational accident during the following 10 years. Snoring alone was not predictive of increased risk of accident.

Treatment does decrease the risk of accidents. Findley et al. (2000) used traffic records to conclude that patients that were treated with nasal continuous positive air way pressure (CPAP) had a lower crash rate while being treated than before treatment. Unfortunately, research is needed to identify those with sleep disorders who are at highest risk of accidents and to evaluate adequate treatment.

6.10 Medications

There is a clear relationship between certain medications such as the sedating antihistamines, neuroleptics, benzodiazepines, tricyclic antidepressants and some psychoactive drugs, and traffic accidents (Adelsberg, 1997; Barbone et al., 1998; Grabe, Wolf, Gratz and Laux, 1999, 1998; Kay, 2000; Logan, Case and Gordon, 2000; Wylie, Thompson and Wildgust, 1993). Recent literature suggest that chronic stable usage of opioids may not impair performance (Fishbain, Cutler, Rosomoff, Steele and Romanoff, 2003; Galski, Williams and Ehle, 2000).

Review of aviation accident data revealed over-the-counter drugs to be the most frequently found drugs in fatal aviation accidents (Canfield et al., 2000). Many of these are known to impair a pilot's ability to safely fly an aircraft. Similar to impairment by alcohol and medical conditions, individuals are poor judges of their degree of impairment caused by medications.

6.11 Provider Knowledge

Health care providers are often unaware of regulatory and legal requirements regarding driving (Cable, Reisnes and Salwa, 2000). In addition, they often have difficulty assessing whether an individual is able to drive safely. Many drivers with head injuries return to driving, including those who report difficulty with behavior, memory, concentration, attention or vision. Few drivers received guidance from their health care provider on driving after an injury or medically disabling condition (King, Benbow and Barrett, 1992).

6.12 Multiple Medical Conditions / Other

Some research has examined the risk associated with multiple medical conditions. Koepsell et al. (1994) compared drivers who were 65 years and older with a matched control group. They found that injury risk was 2.6-fold higher in older diabetic drivers, especially those treated with insulin or oral hypoglycemic agents, those with diabetes for over 5 years and those with both diabetes and coronary heart disease. Sjogren, Eriksson and Ostrom (1996) examined autopsy results of 480 car drivers who died within 3 days of a crash. Almost one quarter had medical

conditions such as heart disease, seizures or diabetes. They estimate that in 6 percent of the cases, the medical condition was the underlying cause of the crash. For drivers over 60, 19 percent of the cases were due to a medical condition. A third study by Vernon et al. (2002) examined all drivers licensed in the state of Utah who reported a medical condition on their license application. The medical conditions group had modestly elevated rates of adverse driving events compared with the control group from the entire driving population. These researchers did not find an increased rate of accidents in drivers with multiple medical conditions. Research conducted by Marshall, Spasoff, Nair and Van Walraven (2002) showed that drivers with a restricted license due to medical condition have a higher crash rate than those without restrictions but have a lower traffic violation rate. However, underreporting of medical conditions and inaccurate assessment of exposure rates may have been weaknesses in this study. In contrast, Yslander (1966) found that the risk of road accidents in Sweden directly caused by chronic diseases, primarily diabetes, cardiovascular disease and renal disorder, or its treatment may be satisfactorily offset by driving restrictions.

One study examined the age, flight experience and risk of crash involvement of a cohort of commuter air carrier and air taxi pilots (Li et al., 2003). The researchers found that flight experience, as measured by total flight time, showed a significant protective affect against the risk of crash involvement. They also commented that the lack of a relationship between age and crash involvement was probably due to the rigorous medical standards and periodic physical examination required for pilots.