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Current and Future Issues Regarding Highway Safety

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16. Abstract

Over the past decade, the State of Michigan has enjoyed continuous increases in traffic safety, including decreased numbers of property-damage-only, fatal and injury crashes, had-been-drinking fatal and injury crashes, and drinking drivers, overall and for teen/young adult and older drivers. These declining trends, combined with other positive developments, such as increasing rates of restraint use, have occurred at the same time that the number of registered vehicles and the VMT steadily increased. In order to assist in the maintenance of these positive traffic safety trends, the Michigan Office of Highway Safety Prevention (OHSP) contracted with the University of Michigan Transportation Research Institute (UMTRI) to conduct a review of the literature to identify current and future issues that have implications for traffic safety in Michigan.

The review covers newly arising issues, as well as issues that are the focus of ongoing efforts to enhance motor vehicle safety. The review encompasses current, as well as historical data from both the state and national levels, and is organized into sections by topic area. The topics are: Sleepiness and fatigue; teen drivers; impaired driving; occupant protection; distracted drivers; aggressive driving; older drivers; construction zones; roadway congestion; homeland security; and large trucks.

The information for the report was compiled in three primary steps. First, an internet search of news and safety websites identified topic areas relevant to traffic safety. Second, a comprehensive literature search, using a variety of databases and information sources, identified current trends in traffic safety and technological advances that had implications for traffic safety. Finally, the information gained from the literature was organized into an annotated bibliography and used to prepare the review narrative with assistance from UMTRI researchers and staff, as well as by OHSP staff members.

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Introduction

Over the past decade, the State of Michigan has enjoyed continuous increases in traffic safety, including decreased numbers of property-damage-only, fatal and injury crashes, had-been-drinking fatal and injury crashes, and drinking drivers, overall and for teen/young adult and older drivers. These declining trends, combined with other positive developments, such as an increasing level of restraint use, have occurred at the same time that the number of registered vehicles and the VMT steadily increased. The combined outcome of these trends is a marked decline in the rates per 100 million vehicle miles of total crashes, personal injury crashes, and PDO crashes. In addition, Michigan's mileage death rates have declined 18.8% from 1993 to 2002. This is a greater reduction than was experienced by the US overall, or any of the five neighboring states with the exception of Indiana (see Table 1) (Office of Highway Safety Planning, 2002).

Table 1. Motor vehicle traffic deaths per 100,000 vehicle miles for the US, Michigan, and neighboring states

	1993	2002	Percent Change
Michigan	**1.6**	**1.3**	**18.75%**
US Overall	1.8	1.6	11.11%
Ohio	1.5	1.3	13.33%
Indiana	1.5	1.2	20.00%
Illinois	1.6	1.4	12.50%
Wisconsin	1.4	1.4	0.00%
Minnesota	1.3	1.1	15.38%

In order to assist in the maintenance of these positive traffic safety trends, the Michigan Office of Highway Safety Prevention (OHSP) contracted with the University of Michigan Transportation Research Institute (UMTRI) to conduct a literature review of current and future issues that have implications for traffic safety in Michigan. The scope of this review includes newly arising issues, as well as important traffic issues that are the focus of ongoing efforts to enhance motor vehicle safety, and encompasses current, as well as historical data from both the state and national levels.

The review is organized into sections by topic area. Rather than have a single Executive Summary, we have elected to begin each section with a bulleted “Overview,” and the body of each section contains nationwide and Michigan-level information, if it exists and is relevant. This approach was selected to provide background and an overall view of each issue, but to also bring it into perspective by relating it to current trends in Michigan. This mode of review is intended to highlight issues that Michigan shares in common with other states and the nation, as well as to identify ways in which Michigan differs. It is our intention that these contrasts between Michigan, its neighboring states and the nation will aid in the design of policy and enforcement programs that will enhance traffic safety in Michigan.

Methods

We completed this project in three primary steps. First, topic areas relevant to traffic safety were identified. In order to create a comprehensive list, a broad net was cast at this stage of the project to ensure inclusion of the most important topics. Potential topic areas were identified by conducting a media search using the internet to locate current issues, events, and technological developments related to traffic safety. The primary purpose of the media search was to ensure that emerging issues that may not appear in other published sources such as published books, government documents, and peer reviewed journals would be included in this review. The list of potential review topics identified by the media search was condensed into a list of primary topics. This list was circulated to experts in traffic safety at UMTRI, who ranked the topics in order of their potential impact on current and future highway safety. The 11 most important topics were selected and used to generate keywords to guide the literature search.

The second step in preparing this literature review was a comprehensive search of the literature to discover the most salient and credible information available on current and future traffic safety issues. A variety of databases and information sources were systematically searched, including PsycINFO, TRIS, Transport Database and other databases of published research and reports on transportation-related websites (e.g., Department of Transportation, National Highway Traffic Safety Administration (NHTSA), Insurance Institute for Highway Safety, and Federal Motor Carriers Safety Administration). The publications that we located during the keyword search were used to guide us to additional relevant information. The information we have included was either printed from an on-line source, or, if not available on-line, the document was retrieved from the UMTRI Library, the University of Michigan Library or through Inter-Library Loan.

As a third step in preparation of this review, the information gained from the literature was organized into an annotated bibliography and used to prepare a preliminary draft of the review narrative. The draft of this report was reviewed and edited by UMTRI researchers and staff, as well as by OHSP staff members, and the feedback from those reviews was used to prepare the final report.

Sleepiness and Fatigue

Overview

- Drowsy driving in the US contributes to 100,000 police-reported highway crashes, 1,500 deaths, and a cost of at least $12 billion each year.

- One half to two-thirds of adults report driving while drowsy, and one quarter report having fallen asleep while driving at least once in the prior year.

- Fatigue-related crashes typically occur during the night, early morning, or mid-afternoon; are likely to be serious; often involve a single vehicle leaving the road; occur more often on a high-speed roadway; do not evidence attempts at crash avoidance; and typically involve drivers who are traveling alone.

- Sleepiness and/or fatigue decreases concentration, response time, reaction speed, and awareness; it impairs judgment, interferes with vehicle management, and increases the risk of human error.

- Causes of sleepiness while driving include restricted amounts of sleep; interrupted or fragmented sleep; long work hours; driving for extended periods of time; driving under the influence of drugs or alcohol; taking sedating medications; not taking breaks to rest from driving; driving at night; poor driving conditions; and poor driver health.

- Drivers at greatest risk of drowsiness while driving include: young drivers ages 16 to 29, especially males; workers whose sleep is disrupted by night shifts, long shifts, or irregular hours; and drivers with untreated sleep disorders.

- Drivers tend to underestimate their drowsiness and many drivers lack an effective plan if they become drowsy while driving.

- Signs of sleepiness or fatigue include: constant yawning; slowed reactions; heavy or sore eyes; blurred vision; poor concentration; impatience; inability to maintain a constant speed; weaving or wandering; reduced ability to use the vehicle controls; and inability to recall having driven the last few miles.

- Remedies for drowsiness include plenty of sleep the night before a long drive; a short nap, especially when drowsy in the afternoon; limiting driving between midnight and 6 AM; limited mid-afternoon driving for older drivers; having a travel companion; and detection and treatment of sleep disorders.

- Rumble strips have been found to reduce road-departure crashes by 30% to 80%.

- Recommended programs to reduce drowsy driving and crashes related to drowsy driving include: public education, targeting the general public as well as high-risk individuals, that provides accurate information about drowsy driving; continued and increased use of shoulder and centerline rumble strips.

Rates of Drowsy Driving

Driving while drowsy is a common high-risk driving behavior. Fatigue contributes to about 100,000 police-reported highway crashes and 1,500 deaths (Department of Transportation [DOT], 2003) in the US, annually. The cost to society of fatigue-related crashes is at least $12 billion a year. However, this is likely an underestimate due to the difficulty of identifying the contribution of fatigue and drowsiness to a crash after a crash has occurred (NHTSA, 2004; Reagle, 1998).

Studies indicate that between 56% and 62% of adults drive while drowsy, with about 27% reporting that they dozed-off while driving at least once in the prior 12 months (Reagle, 1998; Sullivan, 2003). Drowsy driving is also the single most common cause of commercial vehicle crashes (VicRoads, 2001). Typical fatigue-related crashes occur at night, early morning, or mid-afternoon; are likely to be serious; often involve a single vehicle leaving the road; occur more often on a high-speed roadway; do not evidence attempts at crash avoidance; and typically involve drivers who are alone in the vehicle. Sleepiness and/or fatigue can decrease concentration, response time, reaction speed, and awareness, impair judgment, interfere with vehicle management, and increase the risk of human error (DOT, 2003; Sullivan, 2003). These outcomes of drowsiness increase the risk that a vehicle will leave the road, resulting in a “drift-off-road crash.” This serious type of crash is three to five times more severe than other single-vehicle road-departure crashes (Morena, 2003).

Approximately half of US residents report difficulty sleeping. While losing a single night’s sleep can result in acute short-term sleepiness, habitual sleep restriction of as little as one or two hours a night can lead to chronic sleepiness (Connor et al., 2002;

NHTSA, 2004; VicRoads, 2001). Restricted amounts of sleep, and/or interrupted or fragmented sleep are not the only causes of drowsiness. Other contributors include long work hours; driving for extended periods of time; driving under the influence of drugs or alcohol; taking sedating medications; not taking breaks to rest from driving; driving at night; poor driving conditions; and poor driver health, including untreated sleep disorders. However, of all these contributors, the natural circadian wake/sleep cycle (i.e., time-of-day influences on drowsiness while driving late at night, early in the morning, or mid-afternoon) has the strongest effect (NHTSA, 2004). In combination these factors can have a cumulative effect that makes the risk of falling asleep while driving even greater (Connor et al., 2002; NHTSA, 2004).

Recognizing and Responding to Drowsiness

Although no driver is immune to fatigue and sleepiness, three populations of drivers are at greater risk of reduced driving performance due to sleepiness or fatigue. Young people from ages 16 to 29 are at greater risk of sleepy/fatigued driving, and this risk is especially great for men in this age group. Shift workers whose sleep is disrupted by working at night, and working long or irregular hours are more likely to be in a crash resulting from sleepiness or fatigue (NHTSA, 2004). Commercial drivers experience some of the same effects as shift workers, having schedules that often require them to be working at times when they would naturally be asleep (Reagle, 1998). The third group at elevated risk of crashes resulting from sleepiness or fatigue includes individuals with untreated sleep disorders, especially sleep apnea or narcolepsy (NHTSA, 2004).

Restorative sleep is the best remedy for sleepiness (NHTSA, 2004). But, there are other very effective measures of countering the effects of sleepiness and/or fatigue. However, in order to stop for sleep or to utilize other measures, drivers must recognize their own symptoms of fatigue or sleepiness. Research indicates that drivers tend to underestimate their own levels of fatigue or sleepiness (Reagle, 1998; Connor et al., 2002), and many drivers lack an effective plan for addressing fatigue or sleepiness if these occur while they are driving (VicRoads, 2001). Common signs of sleepiness or fatigue include constant yawning, slowed reactions, heavy or sore eyes, blurred vision, poor concentration, impatience, inability to maintain a constant speed, weaving or wandering across the road, reduced ability to use the vehicle controls efficiently (i.e., miscoordination of clutching and changing gears), and being unable to remember having driven the last few miles traveled (VicRoads, 2001).

Once they have recognized their own fatigue, drivers can take effective countermeasures to reduce the effect of sleepiness on driving safety. Planning ahead to get sufficient sleep prior to the trip is important. Sleeping seven to eight hours the night before a long drive is essential to safe travel. After a long drive, or a lengthy period without sleep, only restorative sleep will eliminate sleepiness. Sometimes a short nap is a good remedial measure, especially when drowsiness occurs mid-afternoon on a day following a good night's sleep. Also, 10-20 minutes of sleep may be enough to get a driver safely to his/her destination if it is nearby, or to a hotel or motel where longer periods of sleep can be enjoyed. Limiting the amount of driving between midnight and 6 a.m. is a good countermeasure for drivers of all ages. Limited driving in the mid-afternoon is also an important countermeasure, especially for elderly drivers. Having a traveling companion on long drives is another important precaution (NSC, 2001). Finally, detection and treatment of sleep disorders is essential to safe driving (NHTSA, 2004; VicRoads, 2001).

There are also several myths about methods to reduce sleepiness or fatigue while driving, that are untrue. One myth is that young people can tolerate less sleep better than older drivers, and therefore can drive safely even when they are not getting enough sleep. This is untrue. The lack of sleep reduces the abilities of all drivers to remain awake, be alert, and avoid safety hazards on the road. Another myth is that coffee will keep a driver sufficiently alert to continue driving safely. While coffee may help one avoid falling asleep, it does little to counter the other symptoms of drowsiness, such as reduced concentration. There is also no evidence that opening a window of the vehicle helps rouse a drowsy driver or restore the concentration and alertness needed to drive safely. Playing loud music is also assumed to deter drowsiness, but is more likely to deter the driver's ability to hear warning sounds from the surrounding traffic. Finally, lowering the temperature in the vehicle may delay sleepiness, but will not prevent drowsiness from occurring. It will also not restore a driver to an alert state once s/he is drowsy. Instead keeping the temperature low is most likely to result in a driver feeling both drowsy, and cold (VicRoads, 2001).

Countermeasures

Countermeasures for drowsiness can also be incorporated into the construction of roads and operate independently of the driver. One, for which there is substantial evidence of effectiveness, is rumble strips (DOT, 2003). Shoulder rumble strips alarm and awaken the driver whose vehicle is leaving the road, and centerline rumble strips alert drivers when their vehicle begins to drift into another lane of traffic (DOT, 2003; Sullivan, 2003). Most studies have found that rumble strips reduce road-departure crashes by 30% to 50% (NHTSA, 2004, Reagle, 1998); however, in a study conducted in Michigan, rumble strips resulted in a 40% to 80% reduction in drift-off-road crashes.

The effectiveness of rumble strips can be enhanced by painting the shoulder rumble strips to make them more visible to drivers. Also, rumble strips that are milled into the road surface are more effective than other designs because they allow the wheel to partially drop into them, delivering greater vibration through the steering wheel to the driver (Morena, 2003). Rumble strips have most commonly been used on freeways and other limited-access roads, but are being extended to two-way highways and other secondary roadways in some states. This innovation may be especially useful for reducing fatigue-related crashes on high-speed rural roads (Sullivan, 2003).

Some “high-tech” measures are being developed that will help manage driver fatigue and prevent crashes due to drowsy driving. These devices involve an onboard computer system that monitors drivers for signs of drowsiness and warns the driver if such signs are detected. Dashboard mounted devices can monitor driver drowsiness by measuring the duration of the driver’s eye closures. Lane tracking devices can warn of lane departures. There are also sleep monitors that can be attached to the driver’s wrists. Devices measuring headway and proximity to other vehicles can also alert the drowsy driver to hazardous situations. Regardless of the effectiveness of rumble strip designs, their durability, their use on more roadways, or the advent of new technologies, drivers will need to understand that a warning from one of these devices is not just a signal to take corrective actions, but it is also a potential sign of driver fatigue or sleepiness. These mechanisms should signal the driver to take a restorative break before continuing to drive. Without this understanding by the driver, the effectiveness of any drowsiness or fatigue monitoring/warning device is greatly limited (NHTSA, 2004; Sullivan, 2003).

<u>Actions to be Taken/Continued</u>

Efforts to reduce fatigued and sleepy driving could take several forms. Public education programs could be designed to increase awareness of the dangers associated with drowsy driving. Such programs could also teach methods for addressing drowsiness while driving and dispel common myths about methods for fighting fatigue. These programs could be designed for the general public, but similar approaches could be used to target high-risk groups, such as shift workers, commercial drivers, the elderly, and young drivers. Shoulder and centerline rumble strips are already in use in many parts of Michigan, though centerline rumble strips are less common. Future road designs could include greater use of centerline rumble strips, and these could also be added to high-speed secondary roads, where the risk of crash is higher than on high-speed limited-access roads.

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Teen Drivers

Overview

- High-risk driving behaviors of teens result from immaturity and inexperience.
- Failure to wear safety belts is a major contributor to increased risk of injuries and fatalities in crashes involving teens.
- Michigan and several other states have adopted graduated licensure programs for teens. The number of states with GDL laws in place is steadily increasing.
- Graduated Driver Licensing (GDL) is designed to allow teens to gain driving skills in a reduced-risk setting, while placing clear limits on driving privileges and imposing strong penalties for purposefully driving in an unsafe manner.
- The results of GDL program evaluations strongly support the effectiveness of GDL in preventing crashes involving teen drivers.
- Results of GDL program evaluations also indicate that added driving restrictions are needed to further enhance the safety of teen drivers in Michigan.
    - Increases in privileges should proceed in more numerous, but smaller increments.
    - Advancement to the next level should be contingent on individual driving performance meeting clear standards of safety and expertise (advancement contingent on a good driving record is already a requirement in Michigan).
    - Introduce more restrictions, such as restrictions on passengers.
    - Stronger penalties, such as demotion to a more restricted license, could be the consequence of receiving any moving violation while a graduated license is held.
- Safety belt use among teens is lower than any other age-group. The reasons for this are unclear, but need to be understood before effective programs can be designed to increase teen safety belt use.
- Michigan has the opportunity to take the lead in conducting the research, program development and program evaluation necessary to increase teen safety belt use.

Introduction

Injury resulting from a motor vehicle crash (MVC) is the leading cause of mortality and morbidity among teens (i.e., people 15 to 20 years of age), and numbers of injury and fatal crashes involving teen drivers have increased dramatically in the past decade. From 1992 to 2002 the proportion of teen drivers nationally increased 5.1% from 12.0 million to 12.6 million. Over the same decade the number of teen drivers who died in a MVCs increased 12% from 7,403 to 8,278, and driver fatalities among teens increased 21% from 3,153 to 3,827. In addition, crash risk is increasing more rapidly for teenaged female drivers than for their male age-mates. Fatalities for teen male drivers rose 15% from 2,387 to 2,738 between 1992 and 2002, while the number of fatalities among teen female drivers increased 42% over the same interval, from 766 in 1992 to 1,089 in 2002. In 2002, teen drivers accounted for 6.6% of all drivers, but represented 14.6% of drivers involved in fatal crashes (an over-representation of 2.2) and 16.3% of drivers in police-reported crashes (an over-representation of 2.5). The large number of crashes involving teen drivers is partially due to their inexperience and lack of skill at driving a motor vehicle, but high-risk driving practices such as exceeding the speed limit, following too closely, and improper maneuvers, as well as driving after drinking/using drugs, account for a large proportion of injury and fatal crashes involving teen drivers (NHTSA, 2003).

Teen drivers' MVC risk is low during the learner period when teens are supervised every time they drive. However, MVC risk increases for teens when they begin driving independently, while driving late at night, or with passengers present in the vehicle, especially teenage passengers. Some of these high-risk driving situations are not unique to teen drivers. For example, driving late at night places all drivers at greater risk than driving during daylight hours, however, the risk experienced by teen drivers, who are inexperienced, is generally greater than the risk faced by more experienced drivers. Other risk factors are greater for teens due to their age and stage of development. For example, driving after consuming alcohol places teens at greater risk than adults due to their physiology and the unique effects that alcohol has on teens, as a result. Finally, some risk factors are unique to teens, and must be addressed specifically for this population. A good example is having passengers in the car while driving (Williams, 2003).

High-risk driving behaviors are a major contributor to the high crash risk of teen drivers. These driving behaviors often result from immaturity and poor judgment. Additionally, low rates of safety belt use by teens result in higher rates of injury and fatality crashes. Inexperience is targeted by a number of intervention programs, most notably, graduated driver licensing. High-risk driving accounts for a large part of the heightened crash risk that teen drivers experience, yet risk taking in general and high-risk driving specifically are more difficult to directly target with interventions and may, like inexperience, need to be targeted through driver education and training programs. However, it is not clear that conventional driver education programs reduce crash risk, suggesting the need for more specialized licensure programs (Vernick et al., 1999). Finally, programs designed specifically to increase teen safety belt use are needed.

Graduated Driver Licensing (GDL)

GDL has a long history in other countries, but has only recently been implemented in the United States (US). Thanks to the pioneering efforts of New Zealand, which developed a successful GDL program, the first GDL system was introduced in the US in 1987, and in Canada seven years later (Simpson, 2003). GDL has experienced a rapid increase in popularity in recent years, with many states having implemented GDL programs, and others having enacted GDL laws that have not yet gone into effect. However, there is great variation across programs in the restrictions and regulations imposed, and in some cases the programs appear to be GDL programs in name only (Simpson, 2003). Michigan is one of many states that has taken serious steps to implement an effective graduated licensure program (Shope, Molnar, 2003; Shope, Molnar, Elliott, Waller, 2001).

GDL is based on a foundation of proven educational concepts and principles, and is intended to reduce the risk of injury and death to young and novice drivers while they gain the skills necessary to drive safely and responsibly. Two principal concepts underlying GDL programs are distributed learning and progression from simple to complex skills. Distributed learning means that education is spread over an extended period. This allows time for knowledge and skills to be acquired through practice. Progressing from simple to complex skills allows fundamental skills to be gained first, followed by the addition of more challenging tasks as skills taught in each stage are mastered. The educational principles underlying GDL are to: (a) provide initial experiences under low risk conditions; (b) extend the period of supervised practice to allow time for skills to be gained with the help of an experienced driver; (c) move gradually from less to more complex driving conditions, thereby introducing new challenges and their associated risks slowly; and (d) deliver harsher penalties for deliberate risk-taking, especially during the initial learning phases (Waller, 2003).

Conceptually, there are two general mechanism by which GDL reduces crashes among young drivers, these mechanisms are reduced exposure to risk and greater opportunity to master safe driving skills and develop safe driving habits. The prolonged period of supervised driving that is common across GDL programs serves both mechanisms. It reduces the risk to young drivers' by restricting their driving to occasions when an adult supervisor is available, providing supervision by an experienced driver who can help the young driver recognize and avoid high risk driving situations, and by creating an opportunity for the young driver to practice driving and develop driving skills and habits, both through coaching from the adult passenger riding with them, and through hands-on experience. Nighttime driving restrictions reduce crashes among young drivers by decreasing their exposure to driving in the dark, which is a high-risk driving situation for new drivers. Passenger restrictions are a less commonly implemented component of GDL that also reduces young drivers exposure to risk. Teens are easily distracted, and distractions resulting from the activities of passengers can be especially dangerous for teen drivers who are just learning to drive. The separate contributions of learning and reduced exposure to crash risk among young drivers is not currently known. Ongoing research in several locations, including UMTRI and the University of North Carolina Highway Safety Research Center, are examining these and other issues relating to the effectiveness of GDL in reducing crashes. However, more important than knowing what are the separate contributions of these mechanisms to reduced crash risk, is the fact that GDL programs are effective in reducing the number of crashes involving teen drivers.

Several objections to GDL are commonly raised. One is that lengthening the phase of supervised driving and imposing curfews and other restrictions decreases the mobility of young and novice drivers. Among other complications, decreased mobility and more supervision impose more responsibility on parents to act as a “taxi service” for their children. It also requires parents to take an active and relatively lengthy role as supervisor and teacher of their children as they learn to drive. This leads to a second objection. Parents are not trained driving educators. Some parents may not know how to train their children to drive, while others may neglect this responsibility. Other objections are that some young drivers are “good” drivers, and do not need GDL to drive safely; enforcement of GDL laws is difficult; some young people do not have an available parent to supervise them; administrative costs are too high; and politicians' fear objections from constituents who are parents of novice drivers (Waller, 2003).

In spite of any objections, there is now ample evidence that GDL reduces MVCs among teen and novice drivers (Shope, Molnar, 2003). A study conducted here at UMTRI by Shope and colleagues (2001; Elliot & Shope, 2003; Shope, Molnar, 2004) examined the effects of GDL on crash reduction among teen drivers. The results demonstrated the general effectiveness of GDL in reducing crashes of all types and severities (Foss, Evenson, 1999).

In California, the number of fatal and at-fault injury crashes among 16-year-old drivers declined by 23% and at-fault non-injury collisions of 16-year-olds declined by 17% following implementation of GDL. California is one of the few states where the GDL program places a restriction on the number of passengers that a teen driver can have in the car (i.e., no passengers younger than 20 years old can be transported by someone with a graduated license during the first 6 months of the intermediate stage, unless they are supervised by a 25-year-old driver), and as a result passenger deaths and injuries in vehicles driven by 16-year-old drivers declined by 40% (Simpson, 2003; Shope, Molnar, 2003).

The casualty rate among Florida's 15- to 17-year-old drivers decreased nine percent during 1997, the first full year of graduated licensing in that state. The greatest reduction was among 15-year-olds (a 19% reduction), followed by 16- (an 11% reduction) and then 17-year-olds (a 7% reduction) (Simpson, 2003).

Michigan experienced a 25% decline in per capita collision rates of 16-year-old drivers between 1996 and 1999. There were also significant reductions over this period in nonfatal injury crashes (a 24% reduction) nighttime crashes (a 53% reduction between midnight and 5 a.m.), evening crashes (a 21% reduction between 9 p.m. and midnight), and crashes occurring during the day (a 24% reduction between 5 a.m. and 9 p.m.) (Shope, Molnar, 2003).

The North Carolina per capita crash rate of 16-year-old drivers declined by 23%, or by 27% adjusting for the overall crash trend among drivers ages 25-54 years, after the implementation of the GDL program in that state. Per capita rates for crashes of all severity levels among 16-year-old drivers declined: fatal crashes by 57%; injury crashes by 28%; and non-injury crashes by 23%. Reductions were also observed for both nighttime (a 43% reduction between 9 p.m. and 5 a.m.) and daytime crashes (a decrease of 20%) (Foss, Feaganes, Rodgman, 2001; Simpson, 2003).

In Ohio, preliminary evaluations found that relative to drivers' ages 25-54 years, the overall per-driver crash rate of teen drivers was 23% lower than the rate for teen drivers not in the program. Reductions applied to crashes of all severities: fatal (a decrease of 24%); injury (21% decrease); property damage only (a decrease of 23%); and had been drinking crashes (a 27% decrease in the alcohol-related crash rate) (Simpson, 2003).

Following the introduction of graduated driver licensing in Kentucky, the per-driver collision rate for 16-year-old drivers declined 32%. This lower per-driver crash rate was due to an 83% decrease in the number of collisions occurring during the extended learner stage of the new program which lasts for six months following a teen driver's 16th birthday. In contrast, however, drivers in the intermediate stage (i.e., fewer driving restrictions) who were aged 16.5-17 years had a 3% increase in the number of crashes following the end of the extended learner stage, and no long-term effect of the program was found for 17- and 18-year-old drivers (Simpson, 2003).

The results of these GDL program evaluations strongly support the effectiveness of GDL in preventing MVCs among teen drivers. Decreases are consistently impressive; they leave little doubt that GDL reduces individual morbidity and mortality, and prevents substantial costs to society resulting from lost market productivity, household work losses, travel delays, medical care expenditures, and insurance premiums (Blincoe et al., 2002). The cost of MVCs occurring in the year 2000 totaled $230.6 billion, which equaled a cost of $820 per person living in the US, and 2.3% of the US Gross Domestic Product. Given that teen drivers accounted for 17% of all police reported crashes in 2000, the cost to society for teen crashes in 2000 was, on average, $39.2 billion. In light of this high price tag, it is difficult to imagine justification of any objection to the implementation of GDL.

Michigan has one of the most complete and formal GDL programs of any state, and has benefited from the impressive reductions in MVCs involving teen drivers that have resulted from this program. However, evaluations of non-GDL supervised driving programs suggest that further improvement may be possible, and necessary. These data indicate that the effect of supervised driving on crash risk is greatly reduced once teen drivers begin independent driving (i.e., Level 2 in Michigan). At that time teen drivers' MVC risk increases rapidly (Mayhew, 2003). In addition, the results of data from California suggest that restrictions on teen passengers reduced casualty rates of passengers riding with a teen driver.

As already stated, two principles guiding GDL programs are the provision a safe context for learning, and the introduction of new challenges gradually as previously introduced challenges are surmounted. In order to further protect the lives of teen drivers, it may be necessary to increase challenges and decrease safety measures more slowly for young drivers. This might be accomplished by extending the training period, imposing more restrictions, and easing restrictions in small increment over a longer period. For example, rather than transitioning from a learner license (i.e., Level 1) to an independent license with curfews (i.e., Level 2), which is the current process in Michigan, the transition could proceed in smaller steps that extend the learning/training period. Ways of extending the learning/training period include graduating drivers to next levels more slowly, allowing graduation to the next level only when individual driving performance merits promotion (advancement contingent on a good driving record is already a requirement in Michigan), and the addition of further restrictions (e.g., restrictions on passengers). Additional elements might include demotions that are imposed more readily for poor driving performance. These could be added to current penalties such as demotion to a previous licensure level as a result of moving or had-been-drinking violations (Zwerling, Jones, 1999). Such actions would be in compliance with the third principle of GDL (i.e., the imposition of stronger penalties).

<u>Safety Belt Use</u>

A large body of evidence demonstrates the effectiveness of safety belts in protecting vehicle occupants. It is estimated that in 2001 over 14,000 lives were saved by safety belts (NHTSA, 2002). By reducing the number and severity of injuries, safety belt use also diminishes the substantial economic losses suffered by society as a result of motor vehicle crashes. In spite of increased rates of safety belt use, non-use still contributed to a societal cost of $26 billion in 2000 (Blincoe, 2000).

In spite of the proven effectiveness of this simple intervention, and in spite of historically increasing trends in safety belt use, teens remain the poorest users of safety belts in the US. In 2001, of the 5,341 teens killed in passenger car crashes, approximately two-thirds were not wearing a safety belt at the time of the crash (NHTSA, 2000a). Yet, the threat of traffic crashes to teens' lives would be effectively reduced if they used safety belts every time they traveled in a motor vehicle. Nevertheless, in spite of interventions and policy, teens continue to have the lowest safety belts use rates, and the highest motor vehicle crash-related injury and fatality rates of any age group in the United States (NHTSA, 2003).

The reasons for the lower rate of safety belt use among teens are not well understood. A primary reason for this lack of understanding is that very little research has examined the attitudes, beliefs, and perceptions of teens with regard to safety belt use. Instead, research on safety belt use and promotions to increase safety belt use have been conducted population-wide. Based on the little research that has examined individual level variables, there is evidence that teen safety belt use is associated with lower risk-taking, positive attitudes toward using safety belts (Thuen, Rise, 1998), parent and peer use, perceived benefits of safety belt use (Riccio-Howe, 1991), and psychosocial variables such as good school performance, and family and social well-being (Schichor, Beck, Bernstein, Crabtree, 1990). Use is also related to safety belt comfort, the value placed on having a free choice in deciding to use a safety belt, the belief that driving is risky, and a belief in the belt's ability to achieve its intended purpose (Donahue, 1988).

Two tools have effectively increased safety belt use in the general population and might also be effective with adolescents. The first is primary enforcement, which is already established in Michigan. Primary safety belt laws have a proven record. A good example is increased safety belt use that has consistently followed the passage of primary safety belt laws. The passage of such legislation resulted in an increase in use from 63% to 74% in New Jersey, 58% to 71% in Alabama, and from 70% to 84% in Michigan. The second tool is public information and education (PI&E) programs, such as the “Click It or Ticket” campaign, which combine intense media promotion of safety belt use with primary enforcement of safety belt laws (NHTSA, 2003).

Michigan currently has primary restraint laws in place for drivers and passengers of all ages, with some exceptions for children riding in the back seat of a car. This history, combined with current rates of teen safety belt use, suggests that more needs to be done to motivate teens to use safety belts regularly. Because safety belts effectively reduce morbidity and mortality from traffic crashes, programs that increase safety belt use among teens would save lives and reduce economic losses to society. However, the small amount of research examining teen safety belts use and non-use is not sufficient, and it fails to provide the conclusive information needed to guide the development of effective programs specifically designed to increase safety belt use by teens.

Future Directions

Michigan has the opportunity to take the lead in developing effective safety belt programs for teens. Understanding the processes, opinions and attitudes that contribute to low safety belt use by teens is needed before effective interventions can be designed. Teens in Michigan should be studied for this purpose. Research involving teen focus groups and representative surveys of Michigan teens would provide initial insight needed to begin addressing teen safety belt use. Based on the information gained from research, programs should be designed and evaluated. These new programs could be tested in Michigan, and their effectiveness in increasing safety belt use by teens could be evaluated.

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Impaired Driving

Overview

- Rates of impaired driving have declined over the past decade, but substantial levels persist.
- Declined rates of impaired driving have been especially apparent among drivers under age 21. A primary factor affecting this change was increasing the minimum drinking age from 18 to 21.
- There is substantial public concern about impaired driving, yet many people still report driving within an hour of consuming alcohol.
- The majority of people are in favor of more severe drinking-driving laws.
- Sobriety checkpoints are effective in reducing impaired driving and in raising public awareness. They are also supported widely by the public.
- In Michigan, one out of every 140 miles was driven by someone with a BAC of .10 or higher in 1999 and contributed to 547 crash-related deaths.
- Alcohol contributes to about 26% of all costs due to crashes in Michigan. In 1999 that was equivalent to an average cost of $1.00 per drink consumed state wide.
- Sustained efforts are needed to maintain declining rates of impaired driving, and new programs should be developed, and evaluated, then implemented if proven effective.
- Programs for which there is evidence of effectiveness and that might be tried in Michigan include:
    - Sobriety checkpoints;
    - Prompt driver-license suspension for driving while intoxicated (DeJong, Hingson, 1998);
    - Multi-faceted community-based programs;
    - Mandatory substance abuse assessment and treatment for driving-under-the-influence offenders;
    - Reducing the legal limit for blood alcohol concentrations;
    - Raising state and federal alcohol excise taxes;

- o Compulsory blood alcohol testing for traffic crashes that result in injury; and
- o Special tags that identify repeat offenders.

Rates and Trends

Drivers impaired by drugs or alcohol continue to be a central safety concern, both in law enforcement and in the general population; nevertheless, substantial levels of impaired driving continue. Based on a recent Centers for Disease Control (CDC) report (2003), someone in the US is killed in an alcohol-related motor vehicle crash every 30 minutes. Alcohol-related crashes result in 17,419 deaths in the US in 2002, which represented 41% of all traffic-related deaths (Subramanian, 2001). In addition, alcohol crashes in 2002 resulted in a nonfatal injury every two minutes (NHTSA, 2002). Riding with a driver who had been drinking accounted for nearly two-thirds of all crash-related deaths among children under 15 years of age occurring between 1985 and 1996. More than two-thirds of those drinking drivers were old enough to be the parent of the child killed, and fewer than 20% of the children killed were properly restrained at the time of the crash (Quinlan, 2000).

Drugs other than alcohol (e.g., marijuana and cocaine) have been identified as factors in 18% of deaths among motor vehicle drivers. However, these drugs are generally used in combination with alcohol, making it difficult to estimate their contribution to overall driving impairment and resulting crash-related casualties (NHTSA, 1993).

The enforcement of drink-driving (DD) laws is difficult. As a result, in 2001 over 1.4 million drivers were arrested for driving under the influence of alcohol or narcotics (FBI, 2001), but these arrests only represented about one percent of the 120 million episodes of alcohol-impaired driving that are estimated to have occurred that year (Dellinger et al., 1999). Nevertheless, rates of DD have declined steadily over the past two decades. This decline has been especially apparent among teens and young adults under the age of 21 years. People in this age group experienced a 61% decrease in the rate of involvement in fatal alcohol crashes from 43% in 1982 to 21% in 1998. In comparison, the number of drinking drivers age 21 or older dropped only 33%. The decline in fatal alcohol crash involvement was greatest between 1982 and 1992. In 45 states, involvement of drivers under age 21 in fatal alcohol crashes decreased by more than 50%. The rate of alcohol crash involvement for drivers under age 21 was 5 per 100,000 in the 10 best states in 1998, and 15 per 100,000 drivers under age 21 in the five worst states.

The decline in DD among drivers under age 21 is due to several factors. One is decreased rates of drinking in that age group. Another factor that affected both rates of DD and rates of alcohol consumption among people under age 21 was changes in drinking laws. Between 1983 and 1987, 36 states raised the minimum drinking age to 21. Setting the legal drinking age at 21 years reduced alcohol consumption and DD by restricting availability of alcohol and establishing a greater threat of punishment.

Decreased social acceptability of DD has also contributed to lower rates among drivers under age 21. As a result of this change in social attitudes, drivers in this age group have separated their drinking from their driving more than drivers age 21 and older. Another factor is zero tolerance laws for young drivers, which are now effective in all states. Finally, continuing population-wide campaigns to reduce DD have also helped reduce the number of impaired drivers under age 21 (NHTSA, 2001).

Recent Trends in Drink-Driving

In spite of the positive developments in DD and the public's continued concern about drinking and driving, recent research suggests that progress in a number of key areas has slowed. In November and December of 2001 the Gallup Organization conducted telephone interviews with a US national sample of 6,002 persons age 16 or older. Findings indicated that a majority (62%) of persons of driving age believe that they, themselves, should not drive after consuming two or more alcoholic beverages. Nevertheless, nearly a quarter of the driving-age public had driven in the previous year within an hour of drinking alcoholic beverages. This is about the same level as in 1995. Males were over two times more likely than females to report DD (32% vs. 14%), and adults age 21 to 29 (37% males and 20% female) were the most likely to drink and drive (Royal, 2003).

In terms of amount of driving, drink-drivers surveyed in 2001 made between 809 million and 1 billion driving trips within two hours of consuming alcohol in the previous year. On average, drink-drivers consumed 2.6 drinks within the two hours prior to driving, and about 5% are estimated to have had a BAC of 0.08 or higher while driving. This calculated BAC was slightly lower in 2001 than in 1999, but was similar to 1995 and 1997 estimates. Under-drinking-age drink-drivers consumed an average of 5.1 drinks prior to driving, made only about 3% of all drink-driving trips, but had BAC levels that averaged nearly three times those of legal-age-drinkers. As a result, while their total drink-driving miles are low, under-drinking-age drink-drivers are disproportionately at risk of being in an alcohol-related crash (Royal, 2003).

Problem drinking, which includes alcohol abuse (i.e., binge drinking) and alcoholism (i.e., alcohol dependence) contributes to rates of DD. About 11% of the drinking public over age 16 can be classified as problem drinkers, and yet problem drinkers made up

27% (an overrepresentation of 2.5) of past year drink-drivers, and account for about 46% of all trips in 2001 where driving occurred within two hours after consuming alcohol (an overrepresentation of 4.2). At the time of the interview, problem drinkers were estimated to have had an average calculated BAC of about 0.05 on their most recent trip, as compared with 0.02 for other drinking-drivers (Royal, 2003).

Finding alternatives to drink-driving is not an entirely uncommon practice on a population level, with half of drivers (50%) 16 years of age or older who consumed alcoholic beverages reporting that on at least one occasion in the prior year they had refrained from driving when they thought they might have been impaired. Avoidance of DD is more prevalent among persons under age 30 than among older drivers. The most common means of avoidance was to ride with another driver (63%). However, this alternative is likely to result in riding with an impaired driver. In spite of this, the proportion of people age 16-64 who had ridden with someone in the previous year that they thought might have had too much alcohol to drive safely declined significantly from about 15% in 1991 to 12% in 2001.

Prevention of Drink-Driving

Seventy-one percent of the people who participated in a national survey in 2001 felt that drink-driving penalties should be much (43%) or somewhat more (27%) severe than they were at that time. Not surprisingly, drink-drivers were much less likely than other drivers to want penalties to be more severe (Royal, 2003). However, more severe and strictly enforced penalties have been shown to decrease drink-driving.

Sobriety checkpoints appeared to be effective in reducing drink-driving, and received positive appraisals by survey participants. About one in three participants (32%) in the survey had seen a sobriety checkpoint in the previous year. This was a significant increase from 1995 and is consistent with rates reported in 1999. About 18% had been through a checkpoint at least once themselves, and a majority (62%) felt that sobriety checkpoints should be used more frequently. This level of support was equal to that in 1993, but lower than 1995 to 1999 (Royal, 2003).

Other research has identified various effective measures to prevent injuries and deaths from impaired driving (CDC, 2003). These include:

- Prompt driver license suspension for people who are caught driving while intoxicated (DeJong, Hingson, 1998);
- Lowering permissible levels of blood alcohol concentration to 0.08% in all states (Shults et al., 2001);
- Zero tolerance laws for drivers younger than 21 years old in all states (Shults, 2001).
- Sobriety checkpoints (Shults et al., 2001);
- Multi-faceted community-based approaches to alcohol control and DUI prevention (Holder et al., 2000; DeJong, Hingson 1998);
- Mandatory substance abuse assessment and treatment for driving-under-the-influence offenders (Wells-Parker, Bangert-Drowns, McMillen, Williams, 1995);
- Reducing the legal limit for blood alcohol concentration (BAC) to 0.05% (Howat, Sleet, Smith,1991; National Committee on Injury Prevention and Control, 1989);
- Raising state and federal alcohol excise taxes (National Committee on Injury Prevention and Control, 1989); and
- Implementing compulsory blood alcohol testing when traffic crashes result in injury (National Committee on Injury Prevention and Control, 1989).

Impaired Driving in Michigan

In Michigan, one out of every 140 miles driven in 1999 was by a person with a BAC of 0.10 or more. Driving under the influence resulted in 88,100 alcohol-involved crashes, 547 deaths, and an estimated 29,400 injuries. BACs of 0.10 and higher resulted in an estimated 83,900 crashes that killed 442 and injured 25,700 people. An estimated 1,400 crashes that killed 31 and injured 1,200 involved drivers with BACs between 0.08 and 0.09. Drivers with positive BACs below 0.08 were involved in an estimated 2,800 crashes that killed 74 and injured 2,500. Overall, costs to Michigan residents for alcohol-related crashes in 1999 averaged $6.10 per mile driven at a BAC of 0.10 and above, $2.60 per mile driven at BACs between 0.08 and 0.09, and $0.10 per mile driven with positive BACs lower than 0.08 (NHTSA, 2004).

Alcohol contributes to 26% of the total crash costs to the state of Michigan. The average alcohol-related fatality cost in Michigan is $3.5 million: $1.1 million in monetary costs, and $2.4 million in quality of life losses. The estimated cost per injured survivor of an alcohol-related crash averaged $101,000: $48,000 in monetary costs; and $53,000 in quality of life costs. The total cost to Michigan residents for alcohol-related crashes in 1999 was $4.3 billion, including $2.0 billion in monetary costs and almost $2.3 billion in quality of life losses. On a per-drink basis, the societal cost of alcohol-related crashes in Michigan averaged $1.00 per drink consumed in 1999. The average cost for passengers and drivers of other vehicles involved in alcohol-related crashes was $0.60 per alcoholic drink consumed. Overall, alcohol-related crashes accounted for an estimated 20% of Michigan's auto insurance payments (NHTSA, 2004).

Future Directions

The rate of impaired driving in Michigan has declined over the past decade, but that decline is now flattening. To prevent increases in impaired driving and to maintain a declining trend, several actions might be taken. Some of these have already been taken or are under consideration in other states. Research would be needed to evaluate new programs and in some cases, to help inform program development.

For various reasons, checkpoints are not used in Michigan, yet there is consistent evidence that checkpoints are highly effective in reducing impaired driving. Checkpoints have an important function in mobilizations and in raising the public's awareness of traffic safety issues. Consideration should be given to alternatives to checkpoints that would serve the same purpose, and changes should be pursued to allow the use of checkpoints in Michigan.

Programs that have been active in the past should continue, including mobilizations, public education, and programs in the schools. These programs should be evaluated to determine their effectiveness and worth.

Several other actions to decrease impaired driving are currently under consideration by the Illinois State Legislature (Wallheimer, 2004). These actions include reducing the state's blood alcohol limit from 0.08% to 0.06%, imposing mandatory sentences for motorists who drive under the influence and cause the death of another, and establishing tougher penalties for repeat DUI offenders, including the required use of brightly colored license plates to identify the vehicles of repeat offenders. There is evidence suggesting that these measures may prove effective. In any case research could examine their potential effectiveness, and their acceptability to the public.

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Occupant Protection

Overview

- Safety belt use has increased steadily over the past decade. Current use rates hover around 75% nationally.
- Safety belt use rates are consistently higher in states and territories with primary safety belt laws.
- In 2001 and 2002 only five states had higher rates of safety belt use than Michigan.
- From 2001 to 2002, 17 states showed greater increases in use than Michigan and two tied with Michigan.
- Child restraint use is much higher than safety belt use among adults. Nationally about 95% of infants and 91% of children 1-4 years old are regularly placed in safety seats while in the car.
- In spite of the relatively high rates of child restraint use in Michigan, many children remain at considerable risk of injury or death in a crash due to improper installation and/or use of child safety seats.
- Research consistently shows that the single most effective means of increasing child safety seat use is the passage of legislation that requires it.
- Motorcyclists are at approximately 26 times greater risk of dying if they are involved in a crash than are occupants of passenger cars.
- Helmets are estimated to be only 29% effective in preventing fatal injuries in motorcycle crashes.
- NHTSA estimates that helmets saved the lives of 674 motorcyclists in 2001 and 444 more could have been saved if helmets had been used.
- Helmet use in states with mandatory laws is nearly 100% compared to 34% to 54% in states without mandatory helmet laws, and the repeal of mandatory helmet use laws results in large and rapid increases in injuries and deaths in motorcycle crashes.
- Total traffic deaths in the US increased by 0.4% at the same time motorcycle deaths increased by 10%. This is likely due to decreased helmet use and larger numbers of older motorcyclists who tend to ride bigger, faster, and more powerful motorcycles than younger riders.

Background

The use of occupant protection systems is very important in the US where so many people travel primarily in passenger cars and light trucks. Ejection from a motor vehicle is one of the most injurious events that can occur in a crash, and in fatal crashes about 75% of passengers who are totally ejected from the vehicle are killed. In addition, unbelted occupants inside a motor vehicle place other passengers, even belted passengers, at increased risk of injury resulting from collisions with unbelted occupants who are catapulted by the force of the crash (Cummings, Rivara, 2004).

Seat belts and child restraints are the most effective tools available for decreasing injury and death in crashes. Safety belts reduce the chance of fatal injury by half. The use of properly secured child safety seats reduces infant (i.e., less than 1 year old) fatalities by 71% and toddler (1-4 years old) fatality by 54% in passenger cars. For infants and toddlers in light trucks, reductions in fatalities are 58% and 59%, respectively. It is clear that whether one is an occupant of a passenger car, light truck or a motorcycle, use of appropriate protective devices reduces injury and saves lives. Following, the trends in safety belt and helmet use are reviewed and some of the factors related to use are discussed (Runge, 2002).

Trends in Safety Belt Use

Safety belt use has increased steadily over the past decade. Current use rates hover around 79%, with the highest rates of use in California, Hawaii, Washington, and Oregon where they exceed 90%. The lowest use rates were in New Hampshire where they are only 50% (NHTSA, 2004). In spite of the many lives saved by safety belts each year, about a quarter of the population consists of part-time users.

Safety belt use rates are consistently higher in states and territories with primary safety belt laws. In 2002 safety belt use rates averaged 11 percentage points higher in states with primary safety belt laws than in those without. Nationally, 31 states had secondary laws throughout 2001-2002, and only 17 states, the District of Columbia, and Puerto Rico had primary safety belt laws. New Hampshire has no safety belt law.

In 2001 and 2002 only five states had higher rates of safety belt use than Michigan. From 2001 to 2002, 17 states showed greater increases in use than Michigan and two tied. However, the comparison of increases in use rates must also consider that further increases in use become more difficult to achieve as use rates increase. Because it was ranked sixth in the nation, it was more difficult to increase safety belt use rates in Michigan than it was in states that had lower rates. Nevertheless, further increases are possible and important to achieve (NHTSA, 2002).

Seat belts prevent an estimated 325,000 serious injuries each year and save $50 billion in medical care, lost productivity and other injury-related costs. However, the economic impact of deaths and injuries resulting from restraint non-use highlight the importance of increasing safety belt use. The failure to use safety belts in 2000 resulted in approximately 9,200 unnecessary fatalities and 143,000 avoidable injuries, with a total cost to society of $26 billion (Runge, 2002).

Trends and Issues in Child Restraint Use

Child restraint use is much higher than safety belt use among adults. Nationally about 95% of infants and 91% of children 1-4 years old are regularly placed in safety seats while in the car. The data show that safety seat use is very worthwhile. Of the 529 children under five years of age who died in passenger motor vehicles in 2000, nearly half (251, 47%) were totally unrestrained (Runge, 2002), and among child passengers older than four years, safety belts saved an estimated 11,889 lives in 1999.

In spite of the relatively high rates of child restraint use in Michigan, many children remain at considerable risk of injury or death in a crash. One reason for this is improper installation and/or use of child safety seats. A recent national survey found that 73% of child restraints are misused (NHTSA, 2004). The rate was somewhat higher in a 1999 observational survey conducted in Michigan. That study showed that, 75% of children under age four were in safety seats; however, safety seat inspections found some degree of misuse in 89% of the seats that were inspected (Eby, Kostyniuk, 1999). The most common misuses of child restraints resulted from improper installation of the seat in the car and improper placement of the child in the seat. Safety belts securing the child safety seat in the car are often not tightened sufficiently to prevent the seat from being catapulted forward by the force of a crash. Loose harness straps securing the child in the seat are also hazardous because the force of a crash can eject the child from the seat, or the child can be injured or killed by the force of the crash throwing him/her against loose restraints.

Recently, concern for the safety of children who are placed in safety belts when they out-grow their toddler seats has increased. Safety belts in cars are designed to protect occupants who are adult-sized. As a result, safety belts may not adequately protect a young child, and may even cause injury to a child in a crash. Many agencies now recommend that children between ages four and 11 be placed in booster seats.

Primary enforcement of child safety seat laws can be challenging. For example, it is difficult for police and other enforcement officials to judge the age and size of a child from the outside of a moving vehicle. In addition, the passage of child restraint laws does not prevent the misuse of child safety restraints, and it would be very difficult and potentially ineffective, to legislate the correct use of child safety seats.

Promoting Safety Belt and Child Safety Seats

Research consistently shows that the single most effective means of increasing the use of safety restraints is the passage of legislation that requires it. On average, safety seat use increases by 13% in response to legislation requiring its use and fatalities decrease by 35% (Community Preventive Services, 2002). In studies of booster seat use, when parents are asked what single thing would be most likely to get them to use booster seats, their response was legislation (Community Preventive Services, 2002).

Various effective strategies exist to improve safety belt and child safety restraint use and to promote correct installation of child restraints. Public information and education campaigns can use ads in newspapers, on the radio and TV, billboards, and public service announcements to raise the public awareness of the importance of using safety restraints and to educate people about the importance of correct installation and use of the seat. Drive-up instruction events can also be sponsored. Parents can bring their child and safety seat to the site and receive instruction on the correct installation and use of the restraint they are using. PI&E efforts could also be used to introduce and promote the use of booster seats.

Mobilizations effectively increase safety belt use, and could be applied to both child safety seats and adult safety belt use. Roadside check-points are used by many states, and are effective. These events are an excellent opportunity to educate as well as enforce. Check points heighten the visibility of enforcement activities, and have been shown to be highly effective in changing public behavior. For various reasons, check points have not been used in Michigan. Other programs that achieve the same level of visible enforcement should be developed. In addition, steps should be taken to clear the way for check points to be used in Michigan.

Motorcycle Occupant Protection

Motorcyclists are at approximately 26 times greater risk of dying if they are involved in a crash than are occupants of passenger cars (Shankar, 2001). The greatest contributor to this increased risk to motorcyclists is the nature of motorcycles themselves, which offer very little protection to the occupant when a crash occurs. As a result, the proportion of motorcycle crashes that result in injury or death is very high.

Over 80% of motorcycle fatalities in single vehicle crashes occur off the roadway (i.e., on shoulder, median, roadside, outside of right-of-way, parking lane, separator, gore and other off roadway locations) and almost 60% of motorcycle fatalities occur at night. In 1999 motorcyclist fatalities resulting from single vehicle crashes accounted for 46% of all fatal motorcycle crashes. Half the fatalities in single vehicle crashes were related to problems negotiating a curve. Collision with a fixed object was a significant factor in over half of all motorcycle fatalities in single vehicle crashes.

The high risk of death to a motorcyclist involved in a crash increases cynicism and doubt among motorcyclists regarding the utility of helmet use. Such attitudes cause many motorcyclists to disregard the use of this important safety precaution. To some extent, statistics appear to support this attitude. Eighty percent of motorcycle crashes result in either injury or death. In contrast, helmets are estimated to be only 29% effective in preventing fatal injuries in motorcycle crashes. However, NHTSA (2002) estimates that helmets saved the lives of 674 motorcyclists in 2001 and 444 more could have been saved if helmets had been used. Additionally, helmets are 69% effective in preventing brain injuries (NHTSA, 2002). Brain injuries have serious consequences, and can result in life-long disabilities that severely limit the victim's ability to function normally. Possible outcomes of brain injury include reduced cognitive ability, long-lasting or permanent amnesia, inability to make and maintain social relationships (i.e., marriage, friendships), physical impediments, paralysis and other consequences that can seriously decrease quality of life. The potential of being spared from a brain injury should provide motorcyclists with ample motivation and justification for wearing a helmet in case they are lucky enough to survive a motorcycle crash. In addition, wearing a helmet improves visibility while riding, and protects the rider's eyes and face from debris that might interfere with safe navigation and threaten the safety of passengers and other drivers on the road.

Better quality of life in the event that one survives a motorcycle crash is not the only reason to use a helmet. Many motorcyclists view riding without a helmet to be an expression of personal freedom that should not be restricted by law. Upon examination however, there are many reasons to require helmet use that go beyond the individual. Helmet non-use, like drinking and driving, and failing to wear a safety belt, imposes a substantial cost on society in the form of increased insurance premiums for vehicle damage, medical care and liability, and lost productivity.

Mandatory-use laws effectively improve rates of helmet use, and reduce crash-related injury and loss of life. Helmet use in states with mandatory laws is nearly 100% compared to 34% to 54% in states without mandatory helmet laws (NHTSA, 2002). The repeal of mandatory helmet use laws also provides startling evidence of the effectiveness of this legislation. The 1998 repeal of mandatory helmet use laws in Kentucky and Louisiana resulted in a 50% increase in the number of deaths due to motorcycle crashes in Kentucky and a 100% increase in Louisiana. Injuries in both states also increased, and these increases in injury and fatality persisted when total

VMT were taken into account. In Kentucky the rate of motorcyclists killed per 10,000 registered motorcycles increased from 6.4 in the two years before the repeal to 8.8 in the two years following, and persons injured per 10,000 motorcycles increased from 187 during the two years before to 219 in the two years following the repeal. Similar changes were found in Louisiana, where the fatality rate increased from 4.5 to 7.9 and the injury rate rose from 126 to 152 per 10,000 motorcycles. The repeal of mandatory helmet laws in Texas and Arkansas resulted in similar outcomes (Ulmer, Preusser, 2003).

Helmet use aside, the number of deaths in motorcycle crashes has been increasing steadily for the past few years. Total traffic deaths in the US increased by 0.4% at the same time motorcycle deaths increased by 10% (NHTSA, 2002). This change is partially attributable to less helmet use, which fell from 71% of motorcyclists in 2000 to 58% in 2002.

Another reason for the increase in fatality rates in motorcycle crashes is that the demographics of motorcyclists have changed rapidly in the past 10 years. Motorcycle fatalities have decreased among 20-29 year olds, who were formerly the age group with the most motorcycle fatalities. Meanwhile, fatalities among age 40 and older riders have increased. This shift may be due to substantial increases in the number of older motorcyclists. Older riders typically have larger bikes which are heavier, have more horsepower and greater potential for rapid acceleration and high velocity than smaller bikes that are more common among younger riders (NHTSA, 2002). In addition, older riders are more prone to injury and less able to recover than are younger riders. Taken together, the shift toward larger numbers of older riders and the tendency of these riders toward heavier, faster, and more powerful bikes could be important contributors to increased crashes, and more serious or and long-lasting injuries and fatalities.

Motorcycle Endorsements and Crashes

Very little research has been conducted looking at the association between motorcycle endorsement and motorcycle crash. Kostyniuk (2003), in a study of trends in motorcycle crashes in Michigan, found that the proportion of motorcycle crashes involving motorcycle drivers without an endorsement did not change appreciably from 1997 to 2002. However, only 55-57% of all motorcycle drivers involved in crashes had a valid endorsement, indicating that 43-45% of motorcycle crashes between 1997 and 2002 involved drivers who were not legally licensed to operate a motorcycle. There were differences across age, with motorcyclists age 18 or younger being most likely to not have an endorsement (15% to 23%). Endorsement rates increased steadily across age groups, with motorcycle operators age 65 and over who were involved in a crash having the highest rates of endorsement (73% to 79%). It was also found that over the same six year interval the proportion of motorcycle drivers involved in crashes who did not have an operators license of any kind ranged from 10-12% with the highest rates occurring for motorcyclists under age 18 (ranged from 69% in 1997 to 54% in 2002) (Haapaniemi, 1997; Kelsey, Liddicoat, Ratz, 1986; Schneider, 2003).

These data do not indicate, however, whether the rate of motorcycle crashes is higher among motorcyclists without an endorsement. They do, however, point to a potential problem that may require greater enforcement, stronger penalties, or both. These data and the small amount of published research on the motorcycle endorsement and crashes, point to a need for more research on unendorsed motorcycle operators, motorcycle crash rates among individuals without endorsements, and potential differences in crash characteristics involving endorsed and unendorsed motorcycle operators (e.g., time of day/week, road type, road condition, etc.).

Future Issues

In order to improve helmet use, several questions about motorcyclists, their driving behavior, and factors related to recent increases in motorcycle fatalities need to be answered. Some questions of high importance are:

1- What are the differences in the riding habits and psychological/social characteristics of motorcyclists who are involved in fatal crashes versus those who are not?
2- How does motorcycle crash risk relate to increasing BAC levels?
3- What vehicle, roadway, driver, and rider factors are associated with the recent increases in motorcycle fatalities?
4- Some popular helmets do not meet federal safety specifications. What is the use rate of helmets that are not compliant with federal specifications? An area that would benefit from targeted enforcement is the use of helmets that do not meet federal standards, as mandated by Michigan Law.
5- Other areas in need of further investigation includes methods of providing riders with better rider training, and giving riders greater protection in crashes.

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Distracted Drivers

Overview

- Most drivers are occasionally, if not regularly, engaged in activities that distract them while they are driving.
- On-board technology is being steadily added to cars, and it can contribute to driver distraction.
- Research suggests that on-board technology, such as a navigational device, is more distracting to older drivers than it is to younger drivers.
- Collision warning devices show promise of benefiting drivers and enhancing traffic safety.
- Using voice command rather than manual control devices does not make on-board technology less distracting to drivers, and in some cases vocal interfaces present a worse distraction than manual controls.

Prevalence of Driver Distraction

Most drivers are occasionally, if not regularly, engaged in activities while they are driving that distract them from the safe navigation of their vehicle. We know from research that people are limited in their ability to divide their attention across multiple tasks. As this applies to driving, if distractions occur at inappropriate times (i.e., at a point of high navigational demand), or if the distraction is prolonged, attention to driving can be reduced to an unsafe level (NHTSA, 1998).

The serious threat of driver distraction to traffic safety is brought into sharp relief by a recent survey of drivers, which estimated that over a billion miles are driven weekly by drivers who are distracted by either fiddling with the audio systems of their vehicles, eating, or talking with passengers. The proportion of drivers engaging in each of these common activities was high, ranging from 49% (eating) to 81% (talking with passengers), and most drivers did not recognize that these common distractions can present serious threats to safety. Other less common distractions were rated by the drivers as presenting more serious threats to safety. These included cell phone use for either inbound (26% of drivers) or outbound calls (25% of drivers) while driving, and dealing with children in the back seat (24% of drivers). Driver distraction leads to serious consequences, and between three and four percent of drivers involved in crashes attributed the crash to distraction (including 0.8% looking for something outside of their vehicle and 0.7% dealing with children). Smaller proportions (0.1%) said they had been in a crash caused by cell phone use. In contrast to these data, a 1996 study contracted by NHTSA found that 20% to 30% of all crashes were attributable to driver distraction (NHTSA, 1998).

The gap between self-reported engagement in distracting activities while driving and rates of crashes due to distracted driving released by NHTSA result from the difficulty in identifying driver distraction when it contributes to a crash. Often, by the time officers arrive at a crash scene, evidence of driver distraction as contributing to the crash is no longer accessible. Distraction is often a consequence of events or activities happening when the crash occurs (e.g., distraction by passengers, adjusting on-board electronics). In these cases, the officer is reliant upon the driver to admit that they were distracted at the time of the crash. Another factor contributing to the disparity in crashes due to distraction and self-reported distracting activities while driving is that most distracting activities of drivers do not contribute to a crash. A third reason that NHTSA reported rates are so low is that not all distractions are due to activities of the driver, or of events inside the car. Distractions outside of vehicles frequently take drivers' attention from the road, but these infrequently result in crashes, and when they do, there is insufficient evidence to tie the distraction to the crash. Therefore, NHTSA's reports are based on distractions that are recorded in the police crash record, and these represent a subset of all crashes that result from distractions experienced by drivers.

Clearly, distracted driving is an important safety concern. This issue looms as a great and increasing future concern as more "smart systems" are added to vehicles with each new model year. Much of this technology is intended to either assist or entertain the driver. However, other technology is being increasingly developed and built into cars to warn drivers of roadway hazards. In the end, all these devices result in more on-board functions that can demand a driver's attention, making driver distraction an important current and future traffic safety issue (NHTSA, 1998).

On-Board Technology

Some of the on-board technologies that are currently available or are being developed are listed in Table 2 (Kantowitz, Moyer, 1998; Transport Canada, 2003).

Table 2. Potential Intelligent Transportation Systems (ITS)

Collision Avoidance & Safety (CAS)	Advanced Traveler Information Systems (ATIS)	In-vehicle convenience and entertainment systems
Road departure	Trip planning	Telefax
Rear end	Route guidance	Pager
Lane change/merge	Route selection	Audio systems
Intersection	Multi-modal coordination	Cellular phone
Railroad crossing	Route navigation	Television
Drowsy driver warning	Yellow pages	Mobile PC
Automatic cruise control	Automated tolls	Settings for seats and mirrors
Yaw control	Motorist services	Personal messages (e-mail)
Roadside/emergency services	Vehicle status	
Vehicle location/voice	Regulatory information	
Stolen vehicle location system	Travel advisories	
Theft detection	Road condition	
	GPS	

Before systems such as those shown in Table 2 are developed and placed in motor vehicles they must be integrated into the vehicle's operation so as to minimize driver distraction and maximize the assistance that they are intended to provide to the driver. Technology can present information in many formats, and the selection of presentation format is critical where traffic safety is concerned. Formats should not be selected because they cost the least to produce or have the greatest convenience for vehicle designers and manufacturers (Kantowitz, Moyer, 1998). Instead, the safest formats must be identified and used in vehicle manufacture. Various studies have examined factors related to driver distraction caused by on-board information systems, including driver characteristics and the mode of presentation and formatting of information provided by on-board systems. The goal of this research is to discover ways to maximize the benefit of on-board systems while minimizing the distraction it causes.

ITS and Driver Distraction

Research examining the capacity of drivers to use ITS devices that provide transportation information has suggested that such devices are a mixed blessing for older drivers. Because of diminished perceptual and cognitive abilities, older drivers take longer than younger drivers to obtain and process the information provided by ob-board displays. This lengthens periods of inattention to the roadway and other vehicles. So, while the information provided is potentially beneficial, it is also a threat to traffic safety, especially for older drivers (Mourant et al., 2001).

In one study of age differences in driver distraction older and younger drivers were compared on a divided attention task requiring them to use on-board ITS while driving (Mourant, Tsai, Al-Shihabi, Jaeger, 2001). This study found that switching from views of nearby objects (i.e., the on-board display) to objects far away (i.e., vehicles and signage on the road) was much more difficult for older drivers. As the difficulty of the ITS task increased, so did the separation between older and younger driver performance, with older drivers spending more time out of their intended lane of travel.

Collision warning devices, such as lane drift warnings, proximity alarms, and headway (i.e., distance to a vehicle traveling in front of you) warnings show more promise of being beneficial to drivers and enhancing traffic safety. These systems are intended to prevent collisions by providing the driver with an advanced warning of a potentially dangerous situation. Early warning systems may enhance traffic safety by mitigating the effects of distraction, and by generally helping drivers monitor their driving environments for hazards.

Some ITS instruments have been tested using both manual and voice command entry to determine whether voice controls are less distracting to the driver. One study compared an on-board guidance system with cell phone dialing and radio tuning to test the effects of vocal and manual controls on driver distraction and driving performance. All three systems were associated with lengthier completion times, longer eyes-off-road-ahead times, longer and more frequent glances to the device, and greater numbers of lane departures when manual methods of entry were used as compared with a vocal interface. The voice system was associated with substantially longer and more frequent glances away from the road to an LCD display containing destination (i.e., geographic, telephone number, or radio frequency) information (Tijerina, Parmer, Goodman, 1998; Tijerina, Parmer, Goodman, 1999). In another study, the reaction time of participants in a car-following task who were using voice interface devices was 30% longer (310 milliseconds) than the reaction time of the same drivers in a manual interface condition. Reaction time was increased for expected, as well as unanticipated events when voice controls were being used instead of manual controls. This is similar to reaction times when drivers were using cell-phones, which resulted in a 385-

millisecond increase for expected events and 560-millisecond increase for unexpected events (Lee et al., 2002). In situations where a collision is imminent, a 310-millisecond delay can have serious implications. Comparisons of driver workload in the voice control and manual control conditions indicated that the operation of the voice-controlled e-mail system introduced a significant cognitive load, which increased as verbal demands became greater (Brown, Lee, McGehee, 2001).

These studies have important implications for traffic safety. Put simply, speech-based interfaces are distracting to drivers. They draw upon some of the same cognitive resources that used to drive safely, and they increase the time it takes a driver to react to the actions of other events on the road (Lee, Caven, Haake, Brown, 2002). The effects of voice command systems on driving also apply to cellular telephone use. This is demonstrated by research examining the effects of hands-free cellular phone use on driving performance. The measures of driving performance were reaction time, braking profile, lateral position, speed, and situation awareness. Results showed that drivers were able to have a hands-free telephone conversation and perform well with respect to lateral position and speed maintenance, but their performance on all other indicators of driving performance was worse when they were using a hands-free cell phone compared to a no-cell phone condition. Speaking on a hands-free cellular telephone significantly lengthened the time needed to respond to changing conditions on the road, and diminished drivers' situation awareness. For example, drivers were less responsive to a lowered speed limit when they were using the hands-free cellular telephone, than when the same drivers were not using the phone. The effects of talking on the cell phone were especially apparent early in the phone conversation. In the first two minutes of the phone conversation, the drivers reacted significantly more slowly to events on the road than they did in the remainder of the phone conversation. Perhaps of greatest importance, throughout the telephone conversation drivers were primarily unaware of traffic movements and events happening on the roadway around them (Parkes, Hooijmeijer, 2001).

One way to solve the problem of too much in-vehicle driver information is to remove the driver from the loop when this is appropriate. A principle called the “dark and silent cockpit” has been used in aviation to decrease distractions to pilots. It is based on the idea that information the pilot does not need to know should not be displayed. As an example, if the plane is remaining on course and maintaining altitude, the pilot does not need to be distracted by notification that they are on course and at the correct altitude. On the other hand, if something changed so that the plane began to drift off-course or lose altitude, the pilot would be notified so that corrective action could be taken. The pilot can call up information any time s/he wants but most of the time many displays are quiet (Kantowitz, Moyer, 1998).

As more devices are added to vehicles, cars and trucks start to take on some of the interface characteristics of airplanes (Kantowitz, Moyer, 1998). As an example, a system called the *Phantom* is based on a “radical new design concept” to reduce driver distraction. The *Phantom* would supposedly allow drivers to operate complex systems while keeping attention focused on the road ahead by using technology that includes a Heads-Up Display and controls that are not visible when they are not needed (PR Newswire, 2001). This would, indeed, make the driver seat of a car feel much like the cockpit of an airplane. Many lessons have been learned in the field of aviation that can be applied to the integration of in-vehicle information systems in automobiles (Kantowitz, Moyer, 1998). Perhaps one that should not be forgotten is that pilots receive years of training in order to operate systems such as heads-up displays and silent controls safely and efficiently. Drivers of automobiles receive a small amount of semi-formal training, and many still struggle to safely navigate their low-tech cars and light trucks.

In-vehicle ITS devices are a potential threat to driver safety. Regulations requiring manufacturers to implement integration designs that minimize the potential adverse safety consequences of in-vehicle ITS may reduce the risk presented by these devices. However, further regulatory requirements are clearly needed to lower risk and increase driver safety, including limits on visually distracting devices and open architecture (i.e., able to install additional devices freely) that would allow untested after market plug-and-play devices to be used (Transport Canada, 2003).

One means of reducing the contribution of onboard information and entertainment systems to driver distraction is public education. Programs could be developed that effectively teach drivers about situations on the road when distracting systems should be turned off, or left unattended. Drivers can always choose to let voicemail get their cell phone calls, or to wait to adjust the radio until it is safe to do so. However, public education will not solve the problem. Some individuals will always choose to believe that they are the exceptional person who is able to multi-task safely, even while managing demanding driving situations. These individuals will continue to place themselves, their passengers, and other drivers at risk. For this reason research, including a study ongoing at UMTRI, is looking at on-board systems that can control distractions due to navigation, communication, and entertainment systems when the driver is in a demanding driving situation. Such approaches, if they can be developed to function reliably, could increase driver safety by reducing on-board distractions.

Future Directions

The most immediate implication of this research regards those devices that are already available on the market. Cellular phones are ubiquitous, and the public's awareness of the degree of threat that these devices present when used while driving appears to be deficient. In addition, there are many popular myths about cellular phone use while driving. Perhaps the most common is that hands-free telephones are safe to use while driving. Clearly, this is not the case.

Three areas where immediate action might be taken are in public education, enforcement, and policy development. Greater efforts should be made to educate the public about the danger caused by using a cell phone while driving. These messages can go beyond cell phones, and other on-board devices can also be included. Education efforts could include ads and public service announcements, displays at public events, and the involvement of local groups and organizations.

Enforcement, in this case, cannot begin until laws and policies have been established to regulate the use of on-board communications, navigation, and entertainment devices. Once laws and policies are in place, direct enforcement can be pursued in the form of mobilizations, times of day when enforcement is higher (i.e., rush hour), and similar programs.

Finally, as more ITS devices enter the market, the need for mechanisms and policies to discourage the hazardous use of ITS devices will increase. Similar to safety belts, policies may require manufacturers to design reminder systems into cars to encourage the drivers to take appropriate safety measures. Additionally, devices that manage on-board ITS devices could also be effective in reducing distraction cause by these systems. Even more effective would be laws mandating that certain devices be automatically disabled when the vehicle is in motion (i.e., cell phones).

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Aggressive Driving

Overview

- From 1990 to 1997 almost 13,000 people were injured or killed in motor vehicle crashes resulting from aggressive driving. Red light running alone is responsible for approximately 260,000 crashes each year, of which approximately 750 are fatal.
- The public does not distinguish between aggressive driving and road rage, but in truth aggressive driving and road rage are not the same.
- Aggressive driving includes rude or inconsiderate behaviors like speeding, following too closely, weaving in and out of traffic, cutting in, running red lights, improper signaling, frequent lane changing, cutting other drivers off, and forcing ahead through traffic, that contribute to the risk of motor vehicle crash.
- Road rage is a criminal offense that results from a traffic incident escalating into a far more serious situation involving some type of violence.
- Aggressive driving is done by drivers attempting to reach their destinations sooner, but, ironically, it is a major contributor to congestion and further traffic slow-ups.
- Conditions leading to aggressive driving include congestion and a fast-paced life, which cause drivers to take risks and place themselves and others in peril.
- Rush hour is probably a peak time for aggressive driving.
- People are generally more fearful of aggressive drivers than they are of impaired drivers.

Background

Aggressive driving and road rage are synonymous terms in the public mind. This is likely due to the influence of television and other media outlets that have made the most out of rare, but extreme examples of anger expressed on the nation’s roadways (IIHS, 1998; NHTSA, 2004a). In truth, aggressive driving and road rage are not the same. Aggressive driving includes rude, inconsiderate behaviors that contribute to the risk of motor vehicle crash. Examples of such actions include speeding, following too closely, weaving in and out of traffic, cutting in, running red lights, improper signaling, frequent lane changing, cutting other drivers off, and forcing ahead through traffic. Statistics compiled in 1997 by NHTSA and the American Automobile Association indicated that almost 13,000 people had been injured or killed since 1990 in crashes caused by aggressive driving (NHTSA, 2004b). More recent reports indicate that about 260,000 crashes are caused each year by aggressive drivers, and that about 750 of these are fatal (IIHS, 1998).

Road rage, unlike aggressive driving, is a criminal offense. It results when a driver becomes so angry because of a traffic incident, such as aggressive driving by another motorist s/he responds with violence. Road rage involves the driver's use of the motor vehicle either directly (i.e., running someone down or off the road) or indirectly secondary (i.e., following someone to their destination and attacking them by hand) in the perpetration of violence against another driver (NHTSA, 2004a). Thankfully, events of road rage are relatively rare compared to aggressive driving.

The most common conditions leading to aggressive driving include congestion and fast-paced daily schedules that lead individuals to take driving risks and place themselves and others in peril. Rush hour is probably a peak time for aggressive driving as anxious workers attempt to avoid being late for work, or as tired individuals hurry to get home after a long day at work. As a result, rush hour crashes are frequently caused by aggressive drivers, and 10% of rush hour crashes contribute to a second crash (NHTSA, 2004b). As multiple drivers vie for clear road space, following distances decline, slow-ups are more likely to occur due to congestion and/or crashes, and the numbers of vehicles per mile increases. It is ironic, therefore, that while individuals drive aggressively in an attempt to reach their destinations sooner, their aggressive driving, in combination with that of other drivers, is a major contributor to congestion and traffic slow-ups.

The danger that aggressive drivers present to other people on the roadway is an increasing public concern. In fact, some studies indicate that people are more fearful of aggressive drivers than they are of impaired drivers, with about 60% feeling that aggressive driving is a considerable threat to their safety and the safety of their families (NHTSA, 1998). In part, this is due to the media, which regularly uses examples of the most egregious aggressive driving incidents, and of the most reprehensible acts of road rage to sensationalize these issues and draw a larger audience (NHTSA, 2004a). However, the public's upset over aggressive driving is not all due to media hype. In a NHTSA-sponsored survey, about a third of drivers felt their safety had been threatened by an aggressive driver in the past month, while two thirds felt it had been in the previous year, emphasizing the frequent occurrence of aggressive driving that is serious enough to instill fear in other drivers. Ironically, more than half of the participants in the same survey admitted to driving aggressively, at least occasionally, themselves (NHTSA, 2004b).

In truth, aggressive driving is not a new issue, but is one that has been around since the early days of the automobile, resurfacing periodically as an issue of heightened public concern (IIHS, 1998). The periodicity of aggressive driving in the public mind should not diminish its importance. On the contrary, the endurance of aggressive driving as a traffic concern and a threat to transportation safety highlights its importance. Its persistence as an element of motor vehicle travel and as a threat to public safety emphasizes the need to find new and effective ways of addressing it.

Technology and Reducing Aggressive Driving

Technology is being used to identify and punish aggressive drivers. Cameras are used in many cities in the US and throughout the world to issue tickets for acts of aggressive driving. Photo radar, which takes pictures of speeding vehicles so that tickets can be mailed to violators, has been found to effectively reduce speeding. Public announcements in the news paper and other media are used to educate the public about photo radar, and signs warning drivers about camera locations, but not indicating which cameras are active at any given time, serve as reminders to drivers to maintain the posted speed. In Norway, photo radar reduced injury crashes by 20% on rural roads, and in British Columbia photo radar resulted in a significant reduction in speeding. Cameras are also effective in urban locations, according to a London study that showed a 9% decrease in the number of all crashes and a 56% decrease in fatal crashes after the implementation of photo radar to enforce speed limits (IIHS, 1998).

In Virginia, cameras were found to effectively deter red light running. Drivers were much less likely to run red lights when cameras were present, resulting in a 44% reduction in red light running in the first year of camera enforcement. Similar results were found in Oxnard, California, where violations dropped 42% within four months of the introduction of camera enforcement (IIHS, 1998). In addition to declines in speeding at camera sites, speeding was reduced in non-camera sites, as well. Red light cameras are a highly visible reminder that red light running is serious, and as with photo radar, signs warning drivers of camera locations serve as reminders to obey control signal laws.

Future Directions

Several steps can be taken to reduce aggressive driving. A first step is continuing public education about the differences between aggressive driving and road rage

(NHTSA, 2004a). The equivalence of these two issues in the public eye makes it easier for individual drivers to believe that they are not contributing to the problem because most people do not get involved in the extreme examples of "aggressive driving" (a.k.a. road rage) that are described by the media. Uniformly, all drivers, even aggressive drivers, blame unsafe driving on the "other driver" (NHTSA, 1998). This displacement of blame emphasizes the need for individual aggressive drivers to understand what constitutes aggressive driving, recognize that they are guilty of aggressive driving behaviors, and that they threaten their own safety and that of others every time they drive aggressively.

In addition to education about the nature of aggressive driving, all drivers should be made aware of ways to protect themselves from other drivers who are acting aggressively. The public should also be informed of actions they can take, such as reporting aggressive driving to appropriate law enforcement authorities, that will help discourage aggressive driving (NHTSA, 2004a).

Enforcement activities can also be used to reduce aggressive driving. Some of these, such as mobilizations, can be combined with public education campaigns. Such activities could be used to heighten the visibility of enforcement and to increase public awareness of aggressive driving. Other enforcement-related actions might include imposing higher fines and more points for aggressive driving (NHTSA, 2004c; NHTSA, 1998).

Finally, radar and red-light cameras should be given serious consideration. Their effectiveness is clear, both as a deterrent to aggressive driving, and as a means of lowering crash and fatality rates. Americans generally have serious concerns about privacy and personal freedom. Some very vocal organizations have posed opposition to the use of automated enforcement, but research indicates that this out-spoken sentiment may not be representative of the majority. A recent survey indicated that 72% of city residents and 57% of all residents nationwide, favor the use of automated enforcement devices (IIHS, 1998).

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Older Drivers

Overview

- The US population as a whole is getting older; hence, the number of older drivers (age 65 and older) is expected to increase significantly in the next few decades.
- More elderly people are licensed to drive, and continuing to drive later into life to meet their mobility needs.
- Physical changes associated with aging and disease affect perceptual, motor, and cognitive abilities required for driving an automobile safely.
- Many older drivers compensate for changes in their driving ability by limiting where and when they drive, and by avoiding driving at night, on freeways, in peak traffic conditions, in inclement weather, or alone in unfamiliar locations.
- Vehicle crash rates per mile driven are higher for older drivers than for other drivers, with the exception of those under 25 years of age.
- The risk of dying if they are in a crash is substantially greater for older drivers than for younger drivers.
- With no changes to current crash-related fatality rates, it is estimated that the number of fatalities involving older drivers by 2030 will increase 35% to 71%.
- Society is preparing for the influx of older drivers by considering design changes in roadways and vehicles, introducing technology to assist in driving, and examining alternative modes of transportation for the elderly.

Background

American society is undergoing a demographic transformation that will continue into the middle of the 21st century. Between 1970 and 2000, the population growth of people age 65 and older was almost three times larger than total population growth. The percentage of the population that was age 65 and older was 12.4% in 2000, and is projected to be 21% in 2030 (Chandraratna, Stamatiadis, 2003).

Beyond about age 65, the ability to drive safely begins to steadily diminish, but in this country alternative modes of transportation are limited. The land use and transportation patterns of the United States make public transportation impractical, and transportation is automobile-oriented. As a result, driving is often equated with mobility and independence. The present cohort of older people in the US matured with the automobile, relied on it, and has accumulated little experience with other modes of transportation (Kostyniuk, Shope, 2003). Studies indicate that the majority of older Americans travel by car either as drivers or as passengers to fulfill their local travel needs (e.g., Burkhardt, McGavock, 1999; Chandraratna, Stamatiadis, 2003), and intend to keep driving as long as they possibly can (Kostyniuk, Shope, Molnar, 2001).

Expected Increases in Older Drivers and in their VMT

The number and proportion of older drivers (those age 65 and older) are expected to increase significantly as elderly individuals continue to drive until an older age, and as the overall US population gets older. The number of older drivers increased from 8% of all drivers in 1970 to 13% in 1990. Estimates indicate that in 1995, 78% of persons age 65 and older and 41% of those ages 85 and older had current driver's licenses (Harrison, Ragland, 2003). The number of older drivers is expected to increase 2-2.5 times by 2030 (Burkhardt, McGavock, 1999), and the proportion of older female drivers is also expected to increase.

The proportion of total miles for the entire population that are driven by elderly people is increasing steadily. In 1990, older drivers accounted for 7% of all miles driven. By 2030, it is estimated that miles driven by the elderly will account for 20% of the total national VMT. This is almost triple the 1990 figure. It is estimated the total annual miles driven by older male drivers will increase 465%, from slightly fewer than 100 billion miles in 1990 to over 400 billion miles in 2020. Similarly, miles driven by older female drivers will increase 500%, from slightly less than 50 billion miles in 1990 to approximately 240 billion miles in 2020 (Burkhardt, McGavock, 1999).

Changes in Driving Ability

As people age, physical changes associated with aging and disease can result in the deterioration of abilities that are required to safely drive an automobile (Eby, Trombley, Molnar, Shope, 1998), including visual, auditory, sensate, cognitive, and motor abilities. For example, a decline in peripheral vision can reduce the ability to safely pass approaching vehicles, and decreased range of neck motion may impair the ability to check over the shoulder for traffic or to look behind while backing. Increases in reaction time reduce the ability to respond to unexpected events, and short-term memory loss can interfere with a driver's ability to process information efficiently while driving. These difficulties that arise from growing older are magnified when the older driver must perform maneuvers under stress.

An additional concern is medications. It is typical for elderly people to take several medications to help them cope with the symptoms of aging and/or diseases. However, many medications are sedating, and their effects compound limitations resulting from the normal physical and mental declines associated with aging.

Safety Implications

Older drivers compensate for changes in their driving ability by limiting where and when they drive. Many older drivers avoid driving at night, on freeways, in peak traffic conditions, in inclement weather, or alone in unfamiliar locations (Kostyniuk, Trombley, Shope, 1998). However, despite these driving strategies, vehicle crash rates per mile driven are higher for older drivers than for other drivers, with the exception of those under 25 years of age (Evans, 2000). Among all drivers age 65 and older, it is the oldest drivers who pose the greatest risk to themselves and to public safety. The rate of crashes per mile traveled begins to rise for adults at age 70, and increases rapidly for drivers age 80 and older. In addition, the risk of the oldest drivers dying if they are in a crash is substantially greater than it is for those age 65 to 69. In 1996, drivers age 80 to 84 who were involved in a crash were more than four times as likely to die as were drivers age 65 to 69. When compared to crash-involved drivers of any age group under 65 the difference in the fatality rate is much more dramatic. For instance, drivers age 85+ are more than 11 times more likely to die in crashes than drivers ages 40 to 49. The large difference is attributed in part to the increased physical fragility of the oldest old.

In year 2000, 37,409 Americans died in motor vehicle crashes. Of this number 6,643 were age 65 years and older. This population (i.e., people age 65 and older) represented 13% of the total US population, but accounted for 18% of all traffic fatalities (National Center for Statistics and Analysis, 2001). With no changes to current crash-related fatality rates the number of fatalities involving older drivers by 2030 will increase by three to four times the 1996 level. If this expected increase occurs, the number of older driver traffic fatalities in 2030 will be 35% to 71% greater than the total number of alcohol-related traffic fatalities in 1995 – a level of fatalities that causes serious concern for policy makers and a serious threat to public safety (Burkhardt, McGavock, 1999). Alternatives that will allow the elderly to maintain their mobility and independence while becoming less dependent on driving are desperately needed.

Enhancing Mobility

Society is slowly preparing for the anticipated increase in the number of older drivers and the effect of this increase on transportation safety. Efforts to keep older drivers driving as long as they can do so safely include, taking older drivers limitations into consideration in the design of roads (e.g., Federal Highway Administration, 2001) and vehicles (Vala, 2001; Lupton, 2001), and the use of intelligent transportation system (ITS) technologies in the areas of vision enhancement, collision avoidance, and way-finding. However, as discussed in the section on driver distraction, care must be taken to ensure that such systems are compatible with the needs and abilities of older drivers, and that they enhance safety rather than making the task of driving more complicated and difficult.

There is growing interest in driving assessments to monitor older drivers' ability to drive. Results of the assessments would be intended to identify limits on older people's ability to drive safely and help them avoid driving in conditions that are unsafe for them. These assessments could also be used to determine when older drivers can no longer drive safely. Although the concept of a driving assessment has been around for some time (for a review, see Eby, Trombley, Molnar, Shope, 1998), efforts to evaluate and refine assessment tools have increased (e.g., Staplin, Lococo, Stewart, Decina, 1999; Eby, Molnar, Shope, Vivoda, Fordyce, 2003). There is also a growing emphasis on education, training, and other intervention programs that can help older drivers overcome or compensate for declining abilities, avoid high-risk driving environments, and plan for the time when they can no longer drive (e.g., McKnight, 1988; Ostrow, Shaffron, McPherson, 1992; Marottoli, Drickamer, 1993; Wilkins, Stutts, Schatz, 1999; Owsely, Stalvey, Phillips, 2003).

Other preparations to accommodate future increased numbers of elderly and their mobility needs should focus on the development of appealing mobility options for older persons who do not drive. Short-term improvements to existing public transit services that would make them more elderly-friendly are being explored (Burkhardt, 2003). These include improving schedule reliability, providing "guaranteed rides home," removing potential barriers to public transportation vehicles by the elderly (i.e., mechanisms or designs to make boarding easier), and providing information for trip planning; however, long-term solutions are needed, and planning for future public transportation needs must take the mobility needs of the elderly into account. Customer service features should be added that assist the elderly, such as methods of identifying stops that are accessible to people with hearing and/or vision impairments, identifying seating reserved for older persons, providing more friendly and detailed information, making more travel information telephone lines available, making systems more responsive to complaints, and by expanding areas of service. Better coordination of transit services with human service organizations and partnering with representatives of the aging community will also be needed to meet the current and future mobility needs of the elderly (Burkhart, 2003). Innovative programs for elderly mobility have already been implemented in some communities and are well received by older non-drivers. The Beverly Foundation (2002), identified five volunteer-based programs among the most elder-friendly programs in the country. One program was based on group ownership of a fleet of automobiles that were driven by volunteer drivers (Freund, 1997).

Implications for the Future

Although preparation is underway to accommodate the large number of older drivers and to meet the mobility needs of people unable to drive, there are still many unanswered questions. There is great need for research to better understand the process of driving reduction and cessation and the implications this process has for older peoples' lives. Future research should include more longitudinal studies using large and diverse populations; test strategies to provide pre-cessation planning and educational measures; and explore transportation alternatives. Research is also needed to better define driving competency, and the development of fair, evidence-based assessments that will identify at-risk individuals. Planning and educational programs to support elderly adults, their care-givers, and clinicians also need to be developed.

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Construction Zones

Overview

- The aging roads and bridges in Michigan, as well as the entire US require rehabilitation in addition to regular maintenance to maintain their safety, and are contributing to a larger number of roadway construction and work zones.
- Work activities and construction zones on roadways are associated with increased crash occurrence.
- PI&E and enforcement programs to promote safe passage through roadway construction and work zones are needed.

Background

Most of the freeway system in the United States was completed by the mid 1970s (Transportation Research Board, 1997), and is currently in need of rehabilitation or reconstruction. Furthermore, maintenance of the existing freeways and other roads is an ongoing process. Thus, although there is little construction of new freeways in the United States at the present time, the number of construction and work zones is large and expected to increase as more of the present freeway system is rehabilitated.

Safety Implications

Research from the 1970s to the present has shown that the presence of work activities and construction zones on roadways affects crash occurrence on those roadways. Most of the research examining this issue indicates that work zones increase crash risk from 7%, (Graham, Paulsen, Glennon, 1977; Juergens, 1972; Nemeth, Migletz, 1987) to 20% (Juergens, 1972; Khattak, Khattak, Council, 2002); however, one study estimated an increase of 80% (Rouphail, Zhao, Yang, Fazio, 1988) and a second estimated a 119% increase in crash risk (Liste, Bernard, Melvin, 1976). Although the increased risk varies widely across studies, there is general agreement that construction activity on roadways increases crash rates. Indeed, there are about 700 fatal crashes, 24,000 non-fatal injury crashes, and 52,000 property-damage-only crashes in work zones across the United States each year (Khattak et al., 2002).

Michigan Trends

Since 2001, Michigan Department of Transportation (MDOT) has improved approximately 1,325 miles of state roadway, building 50 miles of passing relief lanes, and upgrading approximately 975 bridges. In that time maintenance has been performed on 4,500 roadway miles. MDOT's goal is to have 95% of freeways and 85% of non-freeway roads under MDOT's jurisdiction in good condition by 2007 and the annual average investment for MDOT's highway program is $1.25 billion per year (MDOT, 2004a). The rehabilitation and maintenance program of roads in Michigan results in a large number of construction and work zones. MDOT (2004b) reported that in 2003 there were 131 separate road projects and 384 bridge structure projects, each of which required a construction or work zone on the roadway. In addition to the work carried out by MDOT, cities and counties also perform construction and maintenance activities on their road systems. Thus, it can be expected that construction and work zones on Michigan's roadways are here to stay, and the next decade will most likely see an increase in the amount of construction and maintenance activity as the aging road infrastructure is rehabilitated.

Strategies to Shorten Construction Duration

The traffic delays and hazards caused by construction and work zones are recognized, and efforts are made to minimize the maintenance and construction duration on roadways. Nationally, there is increasing interest in work-related policy options such as contracting strategies (bonus/penalty for early/late project completion), and technological means (faster construction sequence using pre-cast structural entities) of shortening work duration. A mix of policy and technology options has been used in several cases, including post-earthquake reconstruction in San Francisco, and rapid roadway expansion in Salt Lake City and Atlanta prior to the Olympic Games in those two cities (Khattak et al., 2002). Similar policies and strategies are beginning to be used in Michigan as well.

Implications for the Future

Construction and work zones on roads, especially freeways, are less safe than non-construction and non-work areas. Furthermore, the amount of work and construction activity in Michigan is expected to increase in the foreseeable future. New policies and technology are expected to mitigate the safety issue somewhat by decreasing the duration of road projects, and thereby reducing the exposure of motorists to construction conditions. However, continued PI&E and enforcement programs will be needed to improve the safety of work zones.

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Roadway Congestion

Overview

- The capacity of the US road system has not been expanding fast enough to match growth in traffic volumes.
- Market-based strategies to manage congestion have been pilot-tested in several states.

The Problem

Roadway congestion occurs when traffic volume exceeds roadway capacity. Congestion can result from crashes or other incidents that block the roadway or from regional land use and travel patterns. Besides the obvious effect that congestion has on travel time, it also contributes to decreased traffic safety by increasing driver frustration, leading to aggressive driving, greater traffic density, and increased collision rates.

Roadway congestion in the United States is rooted in the interdependent patterns of land development, automobile availability, and roadway construction. Metropolitan areas in the United States are expanding at rapid rates (Transportation Research Board, 1997). In the 1990s Americans converted open space to developed land at a rate of 2.2 million acres per year, which is 50 times faster than in the 1980s (US Department of Agriculture, 2000). The freeway system within and around metropolitan areas enables commercial and residential development away from city centers. The land most affected by development is that closest to cities and towns and is typically low density, scattered, and automobile dependent. Thus, travel distances, vehicle trips and road usage is increasing, and the VMT has grown consistently. From 1987 to 1996, the population of the US grew by 8.5% from 242.3 million to 262.8 million (US Bureau of the

Census, 2000) and the traffic volume increased by 25% from 1.92 trillion to 21.4 trillion VMT per year (an overrepresentation of 2.9) (FHWA, 1996).

Most of the US freeway system was built by the mid 1970s (Transportation Research Board, 2002) and the capacity of the US road system since that time has not been expanding quickly enough to meet the growing demand for travel. Most capital expenditure on roadways today is spent on renovation, rehabilitation, and widening of existing roadways. Thus, as low density development continues, and VMT grows, road systems in the US are becoming increasingly more congested. Congestion is most prevalent during the peak periods of travel (typically, 7-9 AM and 4-6 PM). A Texas Transportation Institute study (Lomax, Schrank, 2004) reports that nationally, the extra time needed for peak hour travel has tripled during the last two decades. The study also reports that the average commuter in the US spends about 58 hours each year traveling on congested roadways.

Congestion on Michigan's roads is exceeding national trends. Between 1990 and 2000 the mileage of all Michigan roads (state, county, city and village streets) increased by 1.3% (from 118,330 miles to 119,929 miles), and the VMT increased by 16.9% (from 81.2 billion to 94.9 billion; an overrepresentation of 13.0) (Michigan Department of Transportation, 2004). Michigan Department of Transportation (1999) reports that a total of 26% of the VMT on Michigan freeways occurs at or above design capacity, which means that approximately one-quarter of all travel on Michigan's freeways occurs in congested conditions.

Value Pricing Strategies

Recently, the Value Pricing Pilot Program (established by Congress in 1998 under the Transportation Equity Act for the 21st Century [TEA-21]) has pilot tested several market-based strategies for managing traffic congestion. Approximately 30 projects have been pilot tested in 12 states (DeCarlos-Souza, 2003). These strategies, which are all toll-based, represent three approaches to the management of congestion.

The first involves the introduction of "value pricing" strategies to manage congestion by placing tolls on existing toll-free facilities. In such a strategy, low-occupancy vehicles are charged an additional toll for using high occupancy toll (HOT) lanes, while high occupancy vehicles (HOVs) are allowed to use the HOT lanes free or at a discounted rate. HOT lanes operate currently in San Diego, California, and Houston, Texas. Public acceptance of these strategies has been low. In some places, the HOT lanes have been called the "Lexus lanes" and issues of social inequity have been raised. An alternative approach is to apply tolls on all lanes exiting free roads, not just HOV lanes. This concept has been used in Fort Myers Beach, FL. Public acceptance was not overwhelming, with many citizens upset about having to pay for a "good" that was once "free" and already paid for by taxes.

Another strategy is to vary toll amounts on roadways to match variation in demand, and is intended to counter issues of inequity. Called "FAIR" (Fast and Intertwined Regular), this approach separates lanes on congested freeways into regular and fast lanes. The fast lanes are electronically tolled, with tolls set dynamically in real time to ensure that traffic moves at the maximum allowable speed. Users of regular lanes still face congested conditions but are eligible to receive credits if their vehicles have electronic toll tags. Accumulated credits can be used as payment on days they choose to use the fast lanes. This concept is being tested in Alameda County, California; Portland, Oregon; and Houston, Texas.

Still another strategy is to vary tolls on toll facilities based on the time of day, rather than on real-time demand, to encourage some travelers to use the highway when congestion is low. With fewer people traveling during the congested period, the remaining travelers experience better conditions. Toll facilities in California, Florida, New Jersey, and New York have implemented variable tolls.

A final proposed, but untested, strategy is to use vehicles rather than the roadway as the basis of user charges. GPS-based systems would monitor vehicles, and user charges would be imposed depending on the location and time of travel. This idea is to be pilot tested in the Puget Sound area of Washington State, but has received criticism as an invasion of personal privacy.

These market-based strategies are intended to manage congestion, but they also generate revenue. Tolls can be used to finance improvements to highway facilities and to provide alternative transportation options (e.g., buses, rapid transit systems).

Future Implications

Existing projects have demonstrated the feasibility and effectiveness of value-pricing strategies. Value pricing has resulted in improved traffic flow and improved use of roadway capacity, as well as saving fuel, reducing air pollution, and funding transportation projects. However, public acceptance has been low, and presents a significant hurdle. Managing congestion by value pricing may be an option considered in Michigan at some time in the future. However, toll roads have never been part of Michigan's culture, and public acceptance of these strategies may be difficult to achieve. But, without significant changes, growth in low density development and increasing VMT will contribute to greater congestion, motorist frustration, and aggressive driving on Michigan's roadways.

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Homeland Security

Overview

- The terrorist attacks of September 11, 2001, pointed out the vulnerability of the American Transportation system, and led to the creation of the Office of Homeland Security and The Transportation Security Administration (TSA).
- Defending against the vulnerabilities of the transportation system through traditional means such as “guards, guns, and gates” is inadequate.
- There is a need to develop a coherent security system that is well integrated with transportation operations, and deliberately designed to deter terrorist attacks.
- When well integrated with transportation services and functions that confer other benefits, interleaved security layers can confound the would-be terrorist.
- TSA is identifying coherent security systems for each mode of transportation, and is also working with private and public sectors to deploy these systems.
- The trucking and freight sector of the transportation industry is considered to be among the most vulnerable potential targets for terrorists.
- Technologies currently being reviewed for truck security are driver, passenger, and cargo verification systems; vehicle cargo security technologies; vehicle cargo tracking capabilities; and an emergency response system.
- The American Trucking Associations and other trucking industry members have also undertaken the development of an Anti-Terrorism Action Plan.

Vulnerability of the Transportation System

Transportation vehicles and facilities are recurrent targets of terrorist attacks, hijackings, and sabotage (Jenkins, 1997, 2002). The characteristics of transportation systems make them especially vulnerable, and therefore attractive, to terrorists. Passenger vehicles and facilities often contain large numbers of people in enclosed spaces. Vehicles moving rapidly, whether moving in the air, on the surface, or below ground, are in precarious and fragile positions; much damage can be done with the introduction of a relatively small and well-placed force. Certain elements of the transportation infrastructure, such as US flag carriers and landmark bridges and tunnels, are symbolic to Americans, adding further to their appeal as terrorist targets (National Research Council, 2002).

Many transportation facilities and structures are strategically important, serving as key nodes in networks and corridors that handle large volumes of people, goods, and services. Moreover, transportation systems are international in scope, intertwined with economic and social activities, and disruption at key nodes can have far-reaching, long-lasting economic and social effects.

Transportation vehicles and containers can be tempting weapons, as most vehicles are powered by flammable fuels, and some carry bulk shipments of extremely hazardous chemicals. By their nature, these vehicles are highly mobile, and thus capable of being used to access a range of targets quickly. They are also ubiquitous, moving unnoticed within industrial locations, major population centers, and across borders. The mobility, range, and omnipresence of transportation vehicles makes them a ready means of delivering terrorist weapons, from conventional explosives to unconventional biological, chemical, and radiological agents. Terrorists trying to bring weapons of mass destruction into the US could disguise the shipment as ordinary freight. They could also exploit vulnerabilities in transportation information systems to mask their shipments, thus reducing the risk of detection. They could use mail and express mail services to carry weapons into nearly every household, business, and government office in the country (National Research Council, 2002, Wilen, 2003).

Office of Homeland Security and TSA

In the wake of the terrorist attacks of September 11, 2001, President Bush created the Office of Homeland Security, and soon afterward, Congress passed the

Aviation and Transportation Security Act, which established a Transportation Security Administration (TSA) within the US Department of Transportation. TSA was assigned a set of aviation security responsibilities with strict deadlines. Security for other modes of transportation, including surface transportation, was and remains the responsibility of state and local law enforcement authorities, the many public and private entities that own and operate transportation infrastructure and assets, and various federal agencies responsible for port and border security. Currently, the TSA is identifying coherent security systems for each mode of transportation, and is working with private and public sectors in this country and abroad to deploy these systems, and develop support, expertise and new technologies (National Research Council, 2002, 2003).

In developing a strategic plan, the TSA sought advice from the Transportation Panel of the Committee on Science and Technology to Counter Terrorism formed by the National Academies of Science, Engineering, and Institute of Medicine (National Research Council, 2002). The panel concluded that “the transportation system is designed to be accessible and to concentrate passenger and freight flows in ways that can create many vulnerabilities for terrorists to exploit. Prospects for defending against the vulnerabilities through traditional means such as ‘guards, guns, and gates’ are dim. The transportation system is too large, diverse and ever-changing for such blanket approaches to work. Moreover, if applied in the large and diffuse transportation sector, these approaches run the risk of creating a diluted and patchwork collection of poorly connected defenses that disperse security resources while leaving many vulnerabilities unprotected against a terrorist attack.”

The panel argued for the development of a coherent security system that is well integrated with transportation operations and deliberately designed to deter terrorist attacks. In particular, they suggested layered security systems, characterized by an interleaved and concentric set of security features. They note that layered systems cannot be breached by the defeat of a single security feature, as each layer provides backup for others. Moreover, the interleaved layers can confound the would-be terrorist. When well integrated with transportation services and functions that confer other benefits, such as enhanced safety and service quality, layered systems are even more likely to be deployed and maintained over time.

Enhancing Trucking Security

A series of technological approaches for enhancing trucking security are currently under review by the US Department of Transportation. These include driver, passenger, and cargo verification systems; vehicle cargo security technologies; vehicle cargo tracking capabilities; and an emergency response system. These elements are part of an integrated security system and will have benefits to the operators with respect to safety and performance. A program requiring safety permits for carriers of hazardous materials is also being considered. It is currently under deliberation by the Federal Motor Carrier Safety Administration (International Truck and Engine Corporation, 2003).

Operation Safe Commerce (OSC) is a public-private partnership, formed to enhance security of supply chains while facilitating efficient cross-border movement of legitimate commerce. It is intended to prevent terrorists or their weapons from gaining access to the US. The concept is to move away from border crossing checks, and to develop point-of-origin and point-of-delivery mechanisms to ensure safe transport. This will rely on regulations placed on suppliers of products entering the US, as well as the utilization of technologies to monitor and ensure the security of shipment containers (National Research Council, 2003).

The American Trucking Association and other trucking industry members developed an Anti-Terrorism Action Plan (ATAP) (American Trucking Associations, 2004a). ATAP coordinates sets of actions and programs to deter terrorists from utilizing trucks as weapons, or as weapons conveyances. The major programs envisioned by the ATAP include: training professional truck drivers and truck-stop employees to identify and report suspicious activity that may indicate terrorist activity; establish an Industry Highway Watch Operations Center; develop preparedness and response strategies to coincide with government security threat level warnings of possible terrorist attacks; evaluate technologies that could possibly assist the trucking industry to effectively improve the security of trucks, terminals, and other operations; improve industry access to databases that can be used to conduct background searches; expand and strengthen liaison programs with relevant US government agencies; assess vulnerabilities within trucking operations; and provide access to educational and training programs that promote security risk management. It is envisioned that eventually as many as 3 million professional truck drivers in all 50 states would be trained (American Trucking Associations, 2004b, Barthle, 2004).

Implications for the Future

The terrorist attacks on the United States of September 11, 2001, and the emphasis on security are changing the transportation system. It is recognized that the system cannot remain as open as it once was, but conventional security approaches of "guards, guns, and gates" will not be very effective and will also hinder trade and the movement of people. Innovative multi-layered and integrated security systems are being proposed and are currently under development (Barthle, 2004). Technology such as vehicle tracking and vehicle identification, will become an important component of security systems. Security in the information technology portion of transportation operations will also become increasingly important. Some of these changes will be instituted by the private sector in the transportation industry, and some will have to be legislated and federally mediated. There will be negotiations and disagreement about the funding of the additional security measures. The changes in the operations, procedures, and technology to enhance security are ongoing and still developing, and it is difficult to say what the future systems will look like. However, it is certain that they will be quite different from what they were before September 11, 2001.

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Large Trucks

Overview

- Large trucks move freight on the nation’s highways, carrying 71% of the total tonnage of US freight shipments.
- There are about 550,000 separate trucking companies in the US, and approximately 7.9 million large trucks registered in the United States driving approximately 207 million vehicle miles per year.
- Growth in global trade, the “just-in- time” inventory concept, and the North American Free Trade Agreement (NAFTA) have contributed to a 30% increase in the number of large trucks, and a 35% increase in large truck VMT in the last decade.
- The number of large trucks and their mileage is expected to continue growing, especially along traditional east-west and new north-south routes, thereby contributing to increased congestion.

Introduction

A common public view is that large trucks present a threat to safety on US highways. However, traffic records indicate that large trucks have an excellent safety record, and that the number of crashes involving large trucks has declined at the same time that the number of registered large trucks and VMT by large trucks has increased. Crash factors indicating unsafe driving behaviors are noted for only 37% of truck drivers involved in fatal crashes, and are most frequently speeding, not staying in lane, and failing to yield the right of way. Driver fatigue is also a point of traffic safety concern, and has resulted in recent changes in and on-going debate about hours-of-service regulations for truck drivers.

Growth of Freight Movement

Trucks on the nation’s highway system carried 71% of the total tonnage and 80% of the total value of US freight shipments in 1998. More than 550,000 separate trucking establishments carry freight locally, nationally, and internationally. These companies shared total revenue estimated at $342 billion (including local and long-distance trucking and courier services). The companies range from very small, with only several employees and one or two vehicles, to major national networks with large fleets of vehicles and revenues of $2 to $3 billion. Freight movements increased considerably in the 1980s with manufacturing industries going to the "just-in-time" inventory concept, rather than storing raw materials in warehouses. Indeed, some argue that the nation's highways are its new warehouses (National Research Council, 2003).

NAFTA contributed to the robust growth of freight movement in the 1990s. Trade with NAFTA partners grew from 26% of total US trade in 1991 to almost 335 in 1999. Canada is the top US trading partner, accounting for approximately 20% of all US trade. Border crossings at Detroit, Michigan and Laredo, Texas account for the largest portion of land trade by value (over 30% of total value). In 2000, there were over 11.5 million truck crossings into the US from Canada and Mexico, up 26% from 1997. Due to NAFTA, trade with Canada and Mexico is expected to continue expanding and freight movement by trucks will remain the primary mode of transport (Federal Highway Administration, 2004).

Impacts on Congestion

The growth in NAFTA and Latin American trade is affecting land border crossings and intermodal freight connectors. Changes in freight technology, such as increased use of containerized shipping and larger trailers, have created new challenges at ports and border crossing facilities. Larger trucks operating on older access routes often have to deal with short-traffic-signal cycles, inadequate roadway geometrics, and other incompatible local conditions. The combination of large trucks with inadequate infrastructure to support them disrupts traffic flow and contributes to congestion at ports and border crossings, as well as along the common transport routes used by trucks (Federal Highway Administration, 2004).

As trade increases due to NAFTA, highway trade traffic will continue to move along existing US highway corridors that connect major population and manufacturing centers in the US with major ports of entry. It is expected that NAFTA trade will create increased densities of trucks along north-south and east-west corridors running through the northern and southern border regions of the US. Historically, US freight corridors have had an east-west orientation, reflecting the pattern of population growth in the US. This east-west orientation is expected to continue. Highway truck traffic will increase on highway facilities already carrying high volumes of truck traffic resulting in increasingly congested highway facilities. Increased truck traffic and greater congestion can be expected to result in greater driver frustration, more aggressive driving behavior, and reduced traffic safety (Federal Highway Administration, 2004). This is a concern in Michigan as the I-94 and I-96 east-west corridors and the north-south I-275, I75, and US-23 corridors become more congested due to increased truck traffic.

Truck Safety

In 2001, there were 7,857,674 large trucks registered in the United States (4% of all vehicles registered in the US). This represents a 30% increase over the number registered trucks 10 years earlier. Together, these vehicles accumulated 207,686 million VMT in 2001 (7% of all vehicle miles traveled that year). This is a 35% increase in VMT from 10 years earlier (NHTSA, 2003).

In 2002, 434,000 large trucks were involved in traffic crashes, accounting for 8% of all vehicles in fatal crashes, and 4% of all vehicles in injury and property-damage-only crashes. One out of 9 (11%) crash fatalities in 2002 resulted from a crash involving a large truck. Because of the size difference between large trucks and most other vehicles on the road, injuries of occupants of other vehicles are usually more severe than those sustained by occupants of the crash-involved trucks. Of the fatalities that resulted from a collision involving a large truck, 79% were occupants of another vehicle, 7% were non-occupants, and 14% were occupants of the large truck. Of the injuries from crashes involving large trucks, 77% were occupants of another vehicle, 3% were non-occupants, and 20% were occupants of a large truck. (NHTSA, 2003).

The number and proportion of people killed in crashes involving large trucks has been decreasing every year since 1997. In 1997, 5,398 people were killed in crashes involving large trucks, representing 15% of all traffic crash fatalities reported that year (Federal Motor Carrier Safety Administration, 2004). In 2002, a total of 4,897 people died in truck-involved crashes. These deaths accounted for 11% of all 2002 traffic fatalities (NHTSA, 2003), and was a 9% decrease in fatalities from 1997. The crash-involvement rates per registered large truck have also been decreasing. In the 10 years from 1993 through 2003 the fatal crash involvement of large trucks decreased by 19% from 71 to 57 fatal crashes per 100,000 registered large trucks. Over the same period, the rate of involvement in injury crashes decreased by 25% from 1,585 to 1,189 per 100,000 registered large trucks. There was also a reduction of 13% in the involvement of large trucks in property-damage-only crashes from 4,861 to 4,232 crashes per 100,000 registered large trucks (Federal Motor Carrier Safety Administration, 2004; NHTSA, 2003).

The remarkable nature of these statistics is apparent when it is considered that the VMT of large trucks has increased 35% over the last decade (NHTSA, 2003). It is apparent that large trucks, in terms of crash rates, do not present the threat to traffic safety that some individuals believe. Indeed, in 2001, only 37% of large-truck drivers involved in a crash were cited for driver-related factors that contributed to the crash. In comparison, drivers of passenger vehicles involved in a crash were cited in 65% of crashes. Some of the most common factors cited for drivers of large trucks and drivers of passenger vehicles were the same: driving too fast, running off the road or out of the traffic lane, and failure to yield the right of way (Federal Motor Carrier Safety Administration, 2004).

A prominent concern regarding the safety of large trucks has been that drivers' schedules of on-duty-hours and the number of consecutive hours of driving allowed might contribute to driver fatigue and related crashes. Recently, the Federal Motor Carrier Safety Administration revised the hours-of-service regulations for commercial vehicle drivers. The new regulations change the allowable driving hours from 10 to 11, but limit the duty period to 14 hours and place additional restrictions on the duty period (Federal Motor Carrier Safety Administration, 2003). There is currently on-going debate about these new regulations and their relation to traffic safety.

Security Concerns

Assessments of the trucking industry in light of national security after September 11, 2001, show that trucks may be tempting targets for terrorists either as weapons (bulk shipments of hazardous chemicals) or for the transport of weapons. Attacks on the truck freight system would not only be disruptive to the trucking industry but would also disrupt tightly managed supply delivery schedules affecting the manufacturing sector. Attacks on trucks hauling hazardous materials could affect public health, directly. By their nature, large trucks are highly mobile, and thus capable of being used to access a range of targets quickly. They are also ubiquitous, and can move unnoticed in industrial locations, major population centers, and across borders. Their ability to move large quantities or masses of material is also a significant factor in their potential interest to terrorists. The mobility, range, capacity and omnipresence of trucks make them a ready means of delivering terrorist weapons (National Research Council, 2002).

A series of technology approaches for enhancing trucking security are currently under review by the US Department of Transportation. These include driver, passenger, and cargo verification systems, vehicle cargo security technologies, vehicle cargo tracking capabilities, and an emergency response system (International Truck and Engine Corporation, 2003). A program requiring safety permits for carriers of hazardous materials is also being considered and is currently under deliberation by the Federal Motor Carrier Safety Administration (International Truck and Engine Corporation, 2003).

Additional vigilance is also being implemented by the American Trucking Associations (ATA) (American Trucking Associations, 2004a, 2004b). The ATA is proposing a program to train professional truck drivers and truck-stop employees to identify and report suspicious activities that might be indicative of terrorist activity. ATA also intends to: establish an Industry Highway Watch Operations Center; evaluate technologies that could assist the trucking industry to effectively improve the security of trucks, terminals, and other operations; improve industry access to databases that could be used to conduct background searches; expand and strengthen liaison programs with relevant US government agencies; assess vulnerabilities within trucking operations; and provide access to educational and training programs to promote security risk management.

Implications for the Future

Further growth in global and NAFTA trade is expected to result in significant growth in the number of large trucks and large truck VMT. Added congestion on already congested roadways could contribute to driver frustration, aggressive driving, and increased risk of a crash. The need for public information and education programs to teach drivers of passenger cars about the operating characteristics of large trucks and methods of sharing the road safely will be essential.

Even though there are more large trucks on US roads and they are traveling more miles, crash rates at every level of severity have been decreasing steadily (Kostyniuk, Streff, Zakrajsek, 2002). This is an indication of progress, but factors that contribute to increased large truck safety, such as improved infrastructure and public education for drivers of other vehicles, must be continued to maintain this trend. Security concerns are also changing trucking operations. It currently appears that the industry is moving toward vehicle identification and tracking systems, more effective and secure information technology, and increased vigilance among truckers.

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