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Improving Driver Safety with Behavioral Countermeasures
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16. Abstract

The purpose of this project was to provide MDOT with insight regarding the effectiveness of potential implementations of behavioral countermeasures for increasing driver safety in Michigan. The Center for Driver Evaluation, Education, and Research at Central Michigan University performed a series of task including 1) a literature review of driver safety behavioral countermeasures that have been used in the State of Michigan, 2) a literature review of driver safety behavioral countermeasures that have been used nationally, and 3) a pilot study of a countermeasure that was deemed promising for implementation in construction zones. In this report, the findings of the literature reviews are provided as well as

<table>
<tr><td colspan="4">estimations of their potential effectiveness, costs, and implementation issues. The driver safety problem areas covered in this report are alcohol-impaired driving, young drivers, distracted driving, drowsy driving, and older drivers. A review of new and innovative solutions that help improve driver safety behaviors is also included. The results of the pilot study are also discussed as well as their implications for future construction zone design.</td></tr>
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LIST OF ABBREVIATIONS

While abbreviation are defined at their first use in the text, because of 1) the size of the document and 2) the realization that the report may be skipped through instead of merely read from beginning to end, the following abbreviations are provided.

AAA: Automobile Association of America
AAAFTS: AAA Foundation for Traffic Safety
ALR: Automatic License Revocation
ALS: Automatic License Suspension
ATRI: American Transportation Research Institute
BAC: Blood Alcohol Content
CMU: Central Michigan University
DEER: Driver Evaluation, Education, and Research Center
DD: Designated Driver
DOT: Department of Transportation
DWI: Driving While Intoxicated or Impaired
DWU: Driving While Unlicensed
FHWA: Federal Highway Administration
FMCSA: Federal Motor Carrier Safety Administration
GDL: Graduated Drivers License
GHSA: Governors Highway Safety Association
HLDI: Highway Loss Data Institute
IIHS: Insurance Institute of Highway Safety
MDOT: Michigan Department of Transportation
NCHRP: National Cooperative Highway Research Program
NCSDR: National Center on Sleep Disorders Research
NETS: Network of Employers for Traffic Safety
NHTSA: National Highway Transportation Safety Administration
NSC: National Safety Council
NSF: National Sleep Foundation
OHSP: Michigan Office of Highway Safety Planning
PAS: Passive Alcohol Sensor
PBT: Preliminary Breath Test
PSA: Public Service Announcement
RAP: Research Advisory Panel
SVROR: Single-Vehicle-Run-Off-Road
ZT: Zero Tolerance

EXECUTIVE SUMMARY

The purpose of this project was to provide MDOT with insight regarding the effectiveness of potential implementations of behavioral countermeasures for increasing driver safety in Michigan that cannot be gleaned from other reports (e.g., NCHRP report No. 622, Countermeasures that Work). In order to complete the project, the CMU DEER Center committed to performing the following five tasks:

- Task 1: A comprehensive review of national- and state-level behavioral countermeasure practices for the purposes of increasing driver safety
- Task 2: A comprehensive review of State of Michigan behavioral countermeasure practices for the purposes of increasing driver safety.
- Task 3: Synthesis of national- and state-level behavioral countermeasure approaches with approaches that have been implemented in the State of Michigan.
- Task 4: Pilot testing of countermeasures that are deemed to have the highest probability of effective outcomes if implemented in the State of Michigan.
- Task 5: A final report detailing tailored State of Michigan and regional-level driving safety behavioral countermeasure implementation plans.

In this report are a number of recommendations that were generated based on the separate research tasks. Within the review, the effectiveness of each countermeasure is examined (as well as its associated costs and implementation requirements). Further, critical analysis of the factors that contribute to a countermeasures level of effectiveness is discussed. The following table lists all of the countermeasures review in the report as well as their estimated levels of effectiveness, costs, and associated implementation issues. After reviewing the table, if the reader is interested in gathering more information on a particular countermeasure then the table of contents should be consulted.

Finally, the project included an empirical research study for the purpose of testing identified countermeasures that are likely to be effective in the State of Michigan. The objectives and methods of the study were developed after the reviews described above were complete and in consultation with the research manager, program manager, members of the research advisory panel (RAP), and contracted engineering consultants.

This study addressed the overarching objective of developing recommendations for construction zone design that reduce the tendency to increase speed (and promote other safe driving behaviors) as drivers travel through a construction zone. Specifically, the effectiveness of implementing a passive control device (i.e., the manipulation of the spacing between barrels) in a construction zone on speed reduction was investigated. Specifically, we aimed to determine if gradually reducing the spacing of barrels in a construction zone would have an effect on speed maintenance (specifically, would it cause drivers to slow down?). In addition, though no discussion was provided in previous sections, the effect of construction zone length on speed was also investigated.

Twenty subjects participated in the study. Data were collected using the Central Michigan University's AAA Michigan driving simulator. Subjects drove through six driving simulation scenarios; one practice scenario and five experimental scenarios with varying lengths and varying spacing patterns between the barrels. Mean velocity was the primary measure calculated. The effect of the road length and the barrel spacing manipulations were determined by comparing the mean velocity at the beginning of the construction zone (at the end of the taper) and at the beginning of the work zone (where equipment and crew were actually present).

The study demonstrated that through the manipulation of spacing barrels in a construction zone, a driver can be influenced to slow down. Specifically, it was found that a slow gradual reduction of the spacing between the barrels caused greater reductions in velocity than a more rapid reduction in the space between the barrels.

INTRODUCTION

Despite the many strides in transportation safety that have been made, each year thousands of lives and billions of dollars continue to be lost because of motor vehicle crashes. In 2009[1], the U.S. Department of Transportation (DOT) reported that there were 33,808 fatalities as a result of motor vehicle crashes nationwide, which is down 9.7% from 2008 when there were 37,423 fatalities. Injury rates decreased from 2008 to 2009 by 5.5% from 2,346,000 in 2008 to 2,217,000 in 2009. In the State of Michigan in 2009, there were 871 fatalities and 70,931 injuries as a result of motor vehicle crashes (NHTSA, 2011a). A more recent report by the Michigan State Police reports traffic crash numbers of 937 fatalities (an increase of 7.6% from 2009) and 70,501 injuries (a decrease of 0.6% from 2009) in 2010 (see www. michigan.gov/documents/HistoryAtAGlance_82570_7.pdf). In 2010, the total cost to the state as a result of traffic crashes amounted to $ 7,922,073,694 (MSP and OHSP, 2011).

One of the major contributing factors to motor vehicle crashes is alcohol-impaired driving (i.e., driving with a blood alcohol content level above the legal limit). For example, in 2009, 10,839 people died nationally in motor vehicle crashes that were caused by alcohol-impaired driving, accounting for 32% of the total motor vehicle traffic fatalities in the United States (NHTSA, 2011b). In Michigan, while the trend is a reduction in alcohol-related deaths (there was a 5.4% reduction from 2009 to 2010), there were still 283 fatalities in 2010 that resulted from alcohol-impaired driving (NHTSA, 2011a; NHTSA, 2011b).

Another significant contributing factor to motor vehicle crashes are young drivers (typically categorized as those between the ages of 16 and 24 years). In 2009, 2,336 drivers were killed who were age 15 to 20 years and another 196,000 were injured in motor vehicle crashes (NHTSA, 2010a). Young drivers account for a disproportionately large portion of traffic fatalities and injuries in motor vehicle crashes nationally. In 2007, 6.4% of all licensed drivers in the United States were age 15 to 20 years. However, drivers age 15 to 20 years old were involved in 11% of fatal crashes and 14% of all crashes. Further, while young drivers only represent 14% of the entire U.S. population, they are responsible for approximately 30% of total costs of motor vehicle crashes (~$28billion; Finkelstein, Corso, & Miller, 2006).

In Michigan, the problem is just as significant. In the State of Michigan, teen/young adult drivers (age 16-24 years) represented 14.1% of the licensed drivers in 2009 (MSP and OHSP, 2011). The number of teen/young adult drivers in all crashes has decreased by 38.4% since 2000. Their involvement in fatal crashes decreased 50.7% during the same time period. However, as of

[1] The most recent data available is used throughout the report. For some topics, the most recent data available was from 2009 while for others it was 2010. For the most recent data the reader is advised to visit http://www.michigantrafficcrashfacts.org/

2010 teen/young adult drivers were involved in 21.0% of fatal crashes and represented 25.2% of all occupant injuries in crashes (see www.michigantrafficcrashfacts.org/doc/2010/occ_1.pdf).

A third significant contributing factor to motor vehicle crashes are senior drivers. On the national level, in 2009 40 million people (13% of the total U.S. resident population) were age 65 years and older. The percentage of persons 65 years and older is projected to increase to 19% by 2030, and the total number of persons 65 years and older is projected to more than double by 2050 to 88.5 million (Vincent and Velkoff, 2010). And although research has shown that older drivers tend to utilize more protective factors while driving (e.g., wearing a seatbelt, not driving while impaired), the largest number of deaths for a particular age group, besides young drivers, is for drivers who are 80 years or older. This is primarily attributed to declines in cognitive and perceptual abilities, the development of physical or motor-skill impairments, and a general increase in frailty with age. In Michigan, recent crash data show that drivers age 65 years or older were involved in approximately 21% of all fatal crashes in Michigan (MSP and OHSP, 2011).

Additional contributing factors of motor vehicle crashes include aggressive driving (e.g., speeding), distracted driving, drowsy driving, lane departures, and driving through higher-risk zones such as intersection or construction zones. Speeding continues to be a significant factor in a number of motor vehicle crashes. Further, while the actual percentage of motor vehicle crashes that are a result of driver distraction is often debated, data show that at least 20% of all vehicle crashes involve some form of driver distraction (Stutts et al., 2001).

Behavioral Countermeasures

Over the years, hundreds of millions of dollars have been spent addressing a multitude of motor vehicle crash contributing factors through the implementation of behavioral countermeasures (e.g., new legislation, public interest and education). Unfortunately, while the implementation of such countermeasures is well intentioned, they often do not produce the results that are expected. In fact, efficacy of different behavioral countermeasures varies significantly. For example, in NCHRP Report No. 622: Effectiveness of Behavioral Highway Safety Countermeasures, a number of countermeasures are cited that are frequently implemented but have proven to have minimal effectiveness or for which their effectiveness, for multiple reasons (e.g., lack of sufficient data, new traffic safety issue), is simply uncertain or unknown. However, some behavioral countermeasures, when selected appropriately, have been shown to be effective and have produced tangible results (see Table 1).

Table 1. Levels of Effectiveness of a Sample of Behavioral Countermeasures (taken from NCHRP Report No. 622).

Proven Effective	Likely to be Effective	Effectiveness Uncertain or Unknown	Proven Not or Unlikely to be Effective
▪ Booster seat promotions ▪ GDL programs ▪ BAC test refusal penalties ▪ Primary seat belt laws ▪ Sobriety checkpoints ▪ Passive alcohol sensors ▪ Automated speed and red light enforcement ▪ Aggressive driving and speeding penalties ▪ Ignition interlocks	▪ Adult bike helmet laws ▪ Zero-tolerance enforcement ▪ Increased seat belt penalties ▪ Increased parental involvement in driver education ▪ License actions for underage drinkers ▪ Sustained seat belt enforcement	▪ Designated driver programs ▪ Open container laws ▪ GDL penalties ▪ Motorcycle licensing laws ▪ School-based alcohol education programs to reduce impaired driving ▪ Driver distraction laws ▪ Lower BAC limit for repeat offenders	▪ Advanced skill training for teenagers ▪ Traffic violator schools ▪ Road sharing programs (with bicycles and pedestrians) ▪ Motorcycle helmet use promotions ▪ Use of fear and scare tactics in young driver education programs ▪ Aggressive driving laws

There are multiple reasons for some of the low levels of effectiveness of the countermeasures cited above. First, we believe that the implementation of countermeasures requires a programmatic approach in order to realize the highest levels of efficacy. For example, the implementation of primary seat belt use legislation by itself likely would not have increased seat belt use compared to a more programmatic, multi-faceted approach. Subsequent public campaigns and enforcement programs targeting seat belt use have resulted in Michigan becoming one of the top states in seat belt use (98.0% in 2009; NHTSA 2010b). A programmatic approach transitions into a cultural norm as the new patterns are adopted

throughout the population. For example, Michigan children are still far more likely to wear their seat belts in a vehicle than are Michigan adults. In general, children have learned through a combination of practice and verbal reinforcement from their parents and other caregiving adults that putting on a seat belt happens before the car is put in motion. Thus, a programmatic approach should consider 1) the effectiveness of different *combinations* of behavioral countermeasures, and 2) the length and frequency of countermeasure implementation. Second, countermeasures may be implemented inappropriately (e.g., placement of sobriety checkpoints in low violator areas). Third, while the goal of implementing a particular countermeasure is to save lives and reduce costs, the countermeasure may lead to unintended consequences.

Finally, in addition to the reasons discussed above, there are a number of other reasons for investigating the effectiveness of behavioral countermeasures before developing an implementation plan for the State of Michigan, including recent changes in the driving task (e.g., portable electronic devices and vehicle telematics) and the driver population itself (e.g., an increase in proportion of senior drivers).

Behavioral Countermeasures: Where do we go from Here?

It is clear that the impact of motor vehicle crashes is great, and continues to be an area that warrants significant attention. However, before further behavioral countermeasure implementations are conducted in the State of Michigan, two specific questions should be addressed:

1. *Where should Michigan invest safety funding aimed at behavioral modification and education of Michigan's drivers?*
2. *Is it more effective to focus on enhanced enforcement to prevent problems, educating young people, legal penalties or other actions?*

The Central Michigan University (CMU) Center for Driving Evaluation, Education & Research (DEER Center) teamed with external consultants to provide MDOT with the comprehensive research and engineering expertise needed to prepare a tailored behavioral countermeasure implementation plan for the purposes of increasing driver safety. In this and following sections, we provide a comprehensive discussion of significant background research as well as the anticipated benefits of an extensive set of behavioral countermeasures.

Structure and Purpose of the Report

In order to complete the project, the CMU DEER Center committed to performing the following five tasks:

- Task 1: A comprehensive review of national- and state-level behavioral countermeasure practices for the purposes of increasing driver safety
- Task 2: A comprehensive review of State of Michigan behavioral countermeasure practices for the purposes of increasing driver safety.
- Task 3: Synthesis of national- and state-level behavioral countermeasure approaches with approaches that have been implemented in the State of Michigan.
- Task 4: Pilot testing of countermeasures that are deemed to have the highest probability of effective outcomes if implemented in the State of Michigan.
- Task 5: A final report detailing tailored State of Michigan and regional-level driving safety behavioral countermeasure implementation plans.

The structure of this report does not mimic the tasks performed to complete the work. Rather, it should be viewed as a final product that represents the integration of data that was collected over the course of the two year project. While tasks 1 and 2 were performed as separate stages, the purpose of task 3 was to integrate the findings of task 1 and 2. As a result, tasks 1 through 3 are represented herein as the summaries of the various behavioral countermeasures in each of the driver behavior sections (alcohol-impaired driving, young drivers, distracted driving, drowsy driving, older drivers, and innovative solutions). Task 4 is represented by a separate section detailing a study conducted in the DEER Center's AAA Michigan Driving Simulator. Task 5 was the development of the report itself.

The overarching purpose of this report is to provide MDOT insight regarding the effectiveness of potential implementations of behavioral countermeasures for increasing driver safety in Michigan that cannot be gleaned from other reports (e.g., NCHRP report No. 622, *Countermeasures That Work*). While the reports mentioned, as well as many others, provide excellent detail regarding the effectiveness of many countermeasures, they rarely provide enough detail for decision makers in the State of Michigan regarding anticipated levels of effectiveness, costs, and any implementation issues for the State of Michigan specifically. In this report, such issues will be discussed and where possible, recommendations will be provided that are primarily targeted towards Michigan's Strategic Highway Safety Plan and captured in the report. Further, there were many instances in which particular countermeasures or the driver safety problem areas themselves were covered extensively in the previously referenced 'Countermeasures That Work' report and NCHRP report No. 622 (e.g., DWI courts, motorcycle safety). Therefore, these countermeasures or the problem areas were not included in this report. The reader is

advised to access the other reports for information on topics not included in this report. Finally, a number of the countermeasures qualify as engineering approaches but were included in the report because the end objective is to change behavior to improve driver safety.

The recommendations generated were based on a number of separate research tasks. This included a review of behavioral countermeasures that have been used to increase driving safety at both the national- and state-level, with particular attention given to countermeasures that have been used specifically in the State of Michigan. Within the review, the effectiveness of each countermeasure was examined (as well as its associated costs and implementation requirements). Further, analysis of the factors that contribute to the effectiveness of a countermeasure was conducted.

As previously described, while significant improvements have been made in the area of driver safety, gains can still be made. The final objective of the current report is to deliver a comprehensive, effective set of behavioral countermeasures that will guide choices for the State of Michigan and lead to the realization of those gains. This report provides detailed descriptions of each countermeasure identified and documents instances in which the countermeasure has been implemented. Further, particular interest will be paid to the benefits and costs of implementing each countermeasure. In addition, detailed discussion regarding implementation issues of each countermeasure (e.g., labor demands of a countermeasure) are also be presented.

Finally, the project included an empirical research study for the purpose of testing identified countermeasures that are likely to be effective in the State of Michigan. The objectives and methods of the study were developed after the reviews described above were complete and in consultation with the research manager, program manager, members of the research advisory panel (RAP), and contracted engineering consultants. The recommendations provided were based on an empirical validation of their effectiveness and empirical data that supports their implementation.

How to Use the Report

In this report sections have been provided for the following driver behavior problem areas: alcohol-impaired driving, distracted driving, young drivers, older drivers, drowsy driving, and construction zones. In addition, a section on innovative solutions that address the problem areas listed above has been provided. The purpose of the innovative solutions section is to capture information on countermeasure approaches that are just under development or have recently been developed, and for which data on their effectiveness has not been well established.

Following the review of the countermeasures, a section has been provided that details a study aimed at investigating safety issues associated with driving through construction zones. Within

it, whenever the data is available in the literature, anticipated benefits will be stated in absolute numbers (e.g., a decrease in fatalities).

Within each of the countermeasures review sections a rating system was applied based on three dimensions: the effectiveness of the countermeasure, the cost of implementing the countermeasure, and any other implementation issues associated with the countermeasure. Descriptions of each of the dimension are as follows:

Effectiveness. The review has identified what countermeasures have been proven to be highly effective or are deemed as likely to be effective and beneficial, and those countermeasures that have not been as effective. In both instances, discussion regarding reasons for the observed levels of efficacy have been provided.

It should be noted that there are differences in the effectiveness of the same countermeasure across states. Thus, when necessary, the review provides possible explanations for differences between the effectiveness of each countermeasure across states. A number of factors may contribute to differences in the effectiveness of each countermeasure, which need to be considered when tailoring an implementation plan specific for the State of Michigan. For example, differences in penalty and enforcement patterns across states can result in significantly different levels of effectiveness of a particular countermeasure. Thus, not only does the review discuss the different countermeasures that have been conducted at the national- and state-level, but reasons for differences in the efficacies of the countermeasures will be scrutinized in order to avoid drawing erroneous conclusions about their potential effectiveness in the State of Michigan.

Further, while the benefits of each countermeasure will be discussed individually, as previously described, there are occasional instances in which groups of countermeasures are more effective through coordinated, programmatic implementation. For example, the implementation of sobriety checkpoints has been shown to be significantly more effective when coordinated with public interest and education campaigns focused on reducing alcohol-impaired driving. Further, high levels of seat belt use rate can be partially attributed to the coordinated implementation of the primary seat belt law with seat belt use compliance campaigns. In contrast, preliminary data suggests that the lack of a coordinated, long-term approach (e.g., continued enforcement campaigns) minimizes the effectiveness of distracted driving legislation on reducing the use of cell phones while driving (McCartt & Hellinga, 2007).

Finally, it should also be noted that the judgments regarding the effectiveness of the countermeasures are *expert evaluations* provided by the researchers assigned to the project; crash data or other data sources were not consulted to make absolute, quantitative assessments about a countermeasures effectiveness. However, a significant amount of time and effort was committed by the researchers to understanding as much as possible about a particular countermeasures'

effectiveness. Thus, the reader should feel confident that the estimate reflects real-world conditions accurately. However, if the reader wishes to delve deeper into the effectiveness of a particular countermeasure, references have been provided at the end of each section. Thus, the reader is able to retrieve the reports referenced herein and come to their own determination regarding a particular countermeasures' effectiveness.

The following rating system and descriptions of what each rating means was used:

- High: Numerous publications and others sources repeatedly demonstrated the countermeasure to be effective at reducing unsafe driving behaviors.
- Medium: Some publications and others sources repeatedly demonstrated the countermeasure to be effective at reducing unsafe driving behaviors.
- Low: Very few to no publications or other sources were found to repeatedly demonstrate the countermeasure to be effective at reducing unsafe driving behaviors.

Costs. Costs of the countermeasures vary significantly. For example, public interest and education countermeasures tend to be relatively low in cost. In contrast, engineering and roadway management countermeasures that involve significant technology development, engineering, and construction tend to be relatively expensive. The factors that can influence the costs of implementing a countermeasure are numerous and include, but are not limited to, facility and equipment development, personnel costs, infrastructure development and maintenance, and costs associated with promotion/publicity. However, while most costs associated with implementation of a countermeasure are tangible, less tangible costs have also been considered (e.g., outreach efforts necessary to gain acceptance for the intervention or strategy from policymakers and the public). Throughout the review, careful attention was given to the cost of each countermeasure analyzed and documented.

The following rating system and descriptions of what each rating means was used:

- High: Costs are high for reasons such as increased manpower, infrastructure development, etc.
- Medium: Costs are lower because the demands on manpower, infrastructure needs, etc. are less significant.
- Low: Costs are low because the countermeasure can be implemented with current resources (manpower, infrastructure, etc.).

***Implementation Issues*.** While the anticipated effectiveness, benefits, and costs of implementation of each countermeasure are obvious factors to consider, additional factors should also be considered. These include, but are not limited to, public acceptance of the

countermeasure, the current political and economic climate, and anticipated countermeasures technology developments.

The following rating system and descriptions of what each rating means was used:

- High: Implementation will be difficult because of cultural, constitutional, or other societal factors.
- Medium: Implementation will be challenging because cultural, constitutional, or other societal factors, but implementation could be possible.
- Low: There are no real cultural, constitutional, or other societal factors that would prohibit implementation of the countermeasure.

What's not Included?

Benefits of implementing a countermeasure in absolute numbers (e.g., a decrease in fatalities) are not included in the report. Further, a number of sections that would cover other driving behavior issues were not provided. First, there is no section on restraints use for adults or children. Currently, Michigan is near the top in seat belt use and previous efforts have proven to be extremely effective. Thus, the message in this report would simply be to maintain and even increase the approaches already taken. In addition, sections are not provided on bicyclists and pedestrians. Work in those areas was already being conducted by other researchers (as was advised by the research manager, program manager, and members of the RAP). Thus, the CMU DEER Center was directed not to address those areas and focus more on the driver behavior problems areas found herein.

Recommendations for Implementation

The purpose of the project was not to provide the reader with specific directions about what countermeasures to implement. Rather, it was to provide the reader with information that they may not have gleaned from the literature such that informed decisions about what countermeasures to implement (or what changes to previously implemented countermeasures) can be made. This report should be viewed as a resource for MDOT and other agencies to consult when considering the introduction of or modification to behavioral countermeasures in the State of Michigan. As such, the report and its contents should be distributed both within MDOT and shared with other departments and agencies.

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ALCOHOL-IMPAIRED DRIVING

Overview

Nationally, the number of alcohol-impaired driving (i.e., driving with a blood alcohol content level above the legal limit) fatalities decreased from 2008 to 2009 by 7.4%. There were 11,711 alcohol-impaired driving fatalities in 2008 and 10,839 in 2009. (NHTSA, 2009). In 2009, alcohol-impaired driving fatalities represented 32% of all motor vehicle fatalities in the United States (NHTSA, 2009).

In the State of Michigan, the number of alcohol-impaired driving fatalities decreased from 2009 to 2010 by 5.4%. There were 299 alcohol-impaired driving fatalities in 2009 and 283 in 2010. In fact, since 2006, the number of alcohol-impaired driving fatalities in Michigan has reduced every year (see Figure 1).

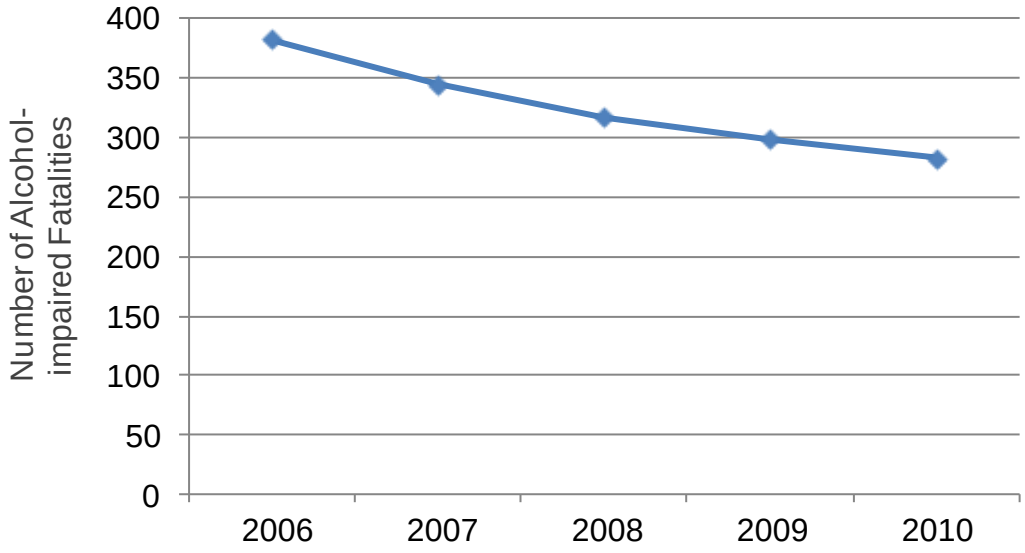

Figure 1. 2005 – 2009 State of Michigan alcohol-impaired driving fatalities (BAC=.08+; see www.michigantrafficcrashfacts.org).

This is encouraging news, but could point to a more general trend in improved driver safety behaviors and not specifically towards a change in alcohol-impaired driving behaviors. While there has been a trend in reduction of alcohol-impaired driving fatalities since 2006, the ratio of alcohol-impaired driving fatalities to total motor vehicle fatalities has remained virtually unchanged. In 2009, alcohol-impaired driving fatalities represented approximately 28% of all motor vehicle fatalities in the United States. Since 2005, this value has ranged between 28% and 31%. This data begs the question, are there significant gains to be made in the area of alcohol impaired driving that haven't been realized?

Tables of Summary Ratings. Table 2 contains an estimate of each countermeasure's effectiveness, cost, and issues for implementation. The ratings follow the system previously described.

Table 2. Estimates of each alcohol-impaired driving countermeasure for effectiveness, cost, and implementation issues.

Countermeasure	Effectiveness	Cost	Implementation Issues
Saturation patrols	High	Medium	Medium
Sobriety Checkpoints	High	Medium	High
Alcohol Detection Devices	High	Medium	Medium
Ignition Interlocks	High	Low	Medium
Responsible Alcohol Practices	Medium	Medium	Medium
Zero Tolerance Laws	Medium	Medium	Medium
Vehicle Impoundment, Immobilization, and Forfeiture	Medium	Medium	Medium
Automatic License Suspension or Revocation	High	Medium	Medium
High BAC Laws	Medium	Low	Low
Designated Driver Programs	Low	Low to Medium	High
Mass Media Campaigns	High	Medium	Low
Court Monitoring	Low	Low	High
Repeat Offenders	Medium	Low	Low

SATURATION PATROLS

Effectiveness: High **Cost:** Medium **Implementation Issues:** Medium

Overview

Saturation patrols are a high visibility enforcement tactic to reduce impaired driving. Saturation patrols consist of a large number of law enforcement officers in an area, whose purpose is to detect and arrest impaired drivers. Unlike sobriety checkpoints, which pull over random vehicles to find impaired drivers, saturation patrols find impaired drivers with officers who are trained to identify driving patterns and other cues that indicate someone may be driving while drunk.

Effectiveness

Saturation patrols have been found to be an effective means in reducing impaired driving. Patrols are most effective when they are publicized heavily and occur often. This is evidenced by the *You Drink, You Drive, You Lose* campaign that Michigan used between 2002 and 2004. Michigan combined saturation patrols and public campaigns with success; the ratio of impaired drivers to sober drivers who were involved in fatal crashes was reduced by 14%, and the number of alcohol-related fatalities per 100 million vehicle miles traveled (VMT) dropped by 18%. It is estimated that one year of Michigan's programs saved 57 lives (Fell, Langston, Lacey, Tippetts, & Cotton, 2008). In the same study, significant decreases in the amount of fatalities caused by impaired drivers were also found in the States of Georgia, Tennessee, and Indiana (note: some of the states also included sobriety checkpoints).

It is worth noting that even though sobriety checkpoints are not legal in the State of Michigan, the consistent use of saturation patrols combined with intensified media resulted in similar and sometimes greater decreases in driving impaired fatalities compared to the other states in the study, resulting in similar or greater amounts of projected lives saved (see Table 3).

Table 3. Projected lives saved and % decrease in impaired driving fatalities in four states included in Fell et al. (2008).

State	Projected Lives Saved	% Decrease in Impaired Driving Fatalities Compared to Neighboring States
Georgia	60	13.97
Michigan	57	17.89
Tennessee	43	10.60
Indiana	25	20.40

Costs

Saturation patrols can be relatively expensive, as they incorporate both increased enforcement and publicity. Saturation patrols do not always require a large number of officers; patrols have been executed on a smaller scale. However, the intense publicity that increases the effectiveness of saturation patrols is expensive.

Implementation Issues

There are a couple of implementation issues with saturation patrols. First, they have high manpower demands and costs. Second, they rely on officers to detect a drunk driver before an incident occurs. However, not all impaired drivers exhibit signs of drunk driving. In addition, even deployment of all the manpower available does not guarantee that a saturation patrol will find all the drunk drivers on a road in a given time.

SOBRIETY CHECKPOINTS

Effectiveness: High Cost: Medium Implementation Issues: High

Overview

At sobriety checkpoints, drivers are randomly stopped and if suspected of driving while intoxicated, are asked to perform a breathalyzer exam. Vehicles are stopped at some regular interval, such as every third or fifth vehicle. The prevailing thought is that sobriety checkpoints serve as a deterrent to driving while intoxicated because of the perceived risk of arrest.

Effectiveness

After reviewing 23 studies that examined the effectiveness of sobriety checkpoint on drunk driving behavior, Shults et al. (2001) found that the number of drivers who blew over 0.08 blood alcohol content or higher reduced by 24% compared to rates prior to checkpoint implementation. The percentage of fatal crashes during the campaign reduced anywhere from 13% to 36% and non-fatal injury crashes reduced anywhere 11% to 23% across the studies. Regarding economic impact, four studies were selected for economic analysis and all showed a positive return-on-investment after a cost/benefit analysis was conducted. Finally, almost all the studies reviewed suggested that to be effective, sobriety checkpoints must be combined with a good public information and education campaign.

Costs

Checkpoints can be expensive to operate. However, though they can be expensive, the previously mentioned studies suggest that the economic benefits of a checkpoint program exceed associated costs. In fact, studies show that for every dollar invested in checkpoints, communities save between six and 23 dollars in costs from alcohol-related crashes, though the most recent data found was from 1998 (Miller et al., 1998).

Implementation Issues

The biggest implementation issue is with constitutional legality. In 1990 the U.S. Supreme Court ruled that sobriety checkpoints are constitutional, but some states (including Michigan) prohibit them based on statutes or from interpretation of state constitutions. This was the key reason that we rated them as "high" on implementation issues. In states that do allow checkpoints, there are strict protocols that must be followed (a list detailing the legality of checkpoints in all 50 states can be found in Appendix A). These include selecting checkpoint locations on the basis of objective criteria (e.g., the incidence of alcohol-related crashes in the area) and stopping cars according to a predetermined system (e.g., every third car that approaches the checkpoint). Other implementation issues include manpower. Supplying manpower has become an issue as the number of officers available has decreased in many communities.

Finally, in general, the use of sobriety check points is supported by community citizens (over 75% approve; see www.nhtsa.dot.gov/people/injury/alcohol/SobrietyCheck/fact_sheet.html).

However, support among law enforcement officials is mixed. Often, checkpoints are viewed as laborious with little return-on-investment (i.e., there are few arrests for alcohol-impaired driving). Law enforcement agencies need to remember (or be reminded) that the purpose of a sobriety checkpoint is to reduce the number of drunk drivers, and not to increase the number of arrests. The goal of the program is to have zero arrests because there are zero drunk drivers on the road. The visible presence of police at sobriety checkpoints helps to reinforce expectations for alcohol-free driving behavior. Culturally, such checkpoints send the message that driving while intoxicated will not be tolerated by the community.

ALCOHOL DETECTION DEVICES

Effectiveness: High **Cost:** Medium **Implementation Issues:** Medium

Overview

Alcohol detection devices are tools that police officers can use during a traffic stop or checkpoint to determine if, and possibly how much, a driver has been drinking. There are two types of detection devices officers can use. The first is called a preliminary breath test device (PBT). PBTs are handheld sensors that are blown into by suspects. Some PBTs give numerical blood alcohol content (BAC), while others only give symbols (such as a light for BACs greater than the legal limit). When stopped by a law enforcement officer for suspicion of driving while intoxicated, the driver may be asked to take sobriety tests including a PBT at the roadside. In Michigan, refusal to take the PBT could result in being charged with a civil infraction and being fined up to $150 plus court costs. Persons under age 21 who refuse to take the PBT receive two points on their driver record. Once the PBT has been administered or refused, the suspect must still take the evidentiary chemical test (blood, breath, or urine test).

The second type of alcohol detection device is called a passive alcohol sensor (PAS). This is a small sensor that is often attached to a flashlight or clipboard and detects the presence of alcohol in the air. PASs can be held near a suspect's mouth to determine if the suspect has been drinking. They can even be used without the suspect's knowledge. Data is provided to the officer almost instantaneously. While they are used outside of sobriety checkpoints, PASs are especially useful in sobriety checkpoints because of the short amount of time officers have to detect intoxication.

Effectiveness

Little hard data exists on the effectiveness of preliminary breath test devices, though law enforcement officers favor their use. In one survey, 69% of 2,731 officers were in support of greater PBT availability and use (Simpson and Robertson, 2001). The use of PBTs can especially help in instances when the driver may not appear impaired after performing some of the standard sobriety tests, but would test over 0.08 BAC.

Passive alcohol sensors have been shown to be effective, especially at sobriety checkpoints. In several studies, officers using a PAS have been shown to make about 50% more arrests of drivers with BACs above .10 than those without a PAS, and using a PAS has been shown to be effective in identifying persons with BACs of 0.10 and greater with detection rates of 70% or higher (Voas, 2008).

Both types of alcohol detection devices are especially useful for drivers with a high tolerance of alcohol (and thus might not display the usual signs of intoxication) and with underage drivers who may be violating zero tolerance laws.

Costs

Both types of alcohol detection devices cost between $450 and $750 per unit. Further, there may be costs associated with training for the effective use of PASs.

Implementation Issues

There are legal issues with using PBTs in some states. Results of PBTs are often inadmissible in court. Some states also have a "one-test" rule, which allow BAC to be measured chemically only once. States with one-test laws do not use PBTs because an evidential BAC test cannot be administered if a PBT has already been given. PASs have been found not to require probable cause because they measure information considered to be "in plain view" (e.g., the smell of alcohol emanating from the suspect).

A smaller issue, but one worth noting, is that some training may be required for the effective use of PASs since these devices may be a new technology to law enforcement. Finally, officers have expressed hesitancy at using PAS in the field because they feel like they can detect the presence of alcohol without the device given how close they have to get to the driver in order to get the device to work. In fact, recent data shows that when officers sense the presence of alcohol and decide to administer a breath test, over 95% of the time drivers score over 0.08 BAC. Of course, this does not include those drivers that may have consumed alcohol and were not tested by officers. It also assumes that test scores for which drivers scored below 0.08 BAC were reported.

IGNITION INTERLOCKS

Effectiveness: High **Cost:** Low **Implementation Issues:** Medium

Overview

An ignition interlock is a device that will only allow a vehicle to be started if the driver has a blood alcohol content (BAC) under a certain threshold (usually 0.02, depending on the state). The device may also require periodic BAC tests during driving. The use of ignition interlocks has grown significantly over the last 20 years, from advent of the "second generation" of interlocks to around 200,000 in 2009.

In Michigan, if a driver has two or more convictions within 7 years or three or more convictions within 10 years, the driver will be labeled as a habitual offender. After a period of license revocation/denial, the habitual offender may be eligible for a driver license appeal hearing. If a restricted license is ordered, it is at that point that an ignition interlock device is placed on the vehicle that the habitual offender owns or intends to operate. The person cannot drive until the device is properly installed and proof of installation is presented to a local Secretary of State branch office. As of October 31, 2010, anyone with a restricted license that requires an ignition interlock device must continue to drive with the device until the Secretary of State authorizes him or her to remove it.

Effectiveness

Several studies have shown ignition interlocks to be effective. In 2004, Beirness and Marques reported that in the 10 ignition interlock programs that they investigated, driving while intoxicated (DWI) recidivism was reduced in offenders who had an interlock installed by 50%, sometimes more, as compared to offenders without ignition interlocks. Further, DeYoung, Tashima, and Masten (2004) found interlocks reduced the risk of a crash by 42% in offenders with an ignition interlock compared to offenders who had not had an interlock installed. However, the effectiveness of ignition interlocks is consistent only while the device is in the vehicle. Once ignition interlocks are removed from vehicles, recidivism rates of ignition interlock users are similar to the rates for offenders who did not install ignition interlocks (Beirness, 2001; Coben & Larkin, 1999; Marques, Tippets, Voas, & Beirness, 2001; DeYoung, 2002; Raub, Lucke, & Wark, 2003); such data suggest that ignition locks are not paired with behavioral health programs to reduce alcoholism.

Costs

The offender must pay ignition interlock charges, and costs vary. The device installation usually costs about $200. Offenders must also pay to rent the interlock while it is in the vehicle, which often costs about $75 per month. In Michigan, the law limits the amount that can be charged to low income persons to a maximum of $2.00 per day.

Administration costs vary with the design of each ignition interlock program. Mandatory ignition interlock sanctions, or requiring interlocks for first-time offenders, will incur greater costs. However, ignition interlock costs are far less than the costs of incarceration or electronic monitoring. Research shows that the public saves $3 to $7 for every $1 spent on ignition interlock devices for DWI offenders (Miller & Hendrie, 2005).

Implementation Issues

Although proven to be an effective device, no state program has yet been developed that utilizes the device to its full potential. In California, which has a long history with ignition interlocks, judges often do not order ignition interlock installation, and when they do order offenders to install one, the installation often never occurs. Offenders may claim they don't have a car, or delay appointments until the device is never put on. Unfortunately, many offenders often continue to drive (sometimes while impaired by alcohol) in these instances even though their license may have been suspended (Baker et al., 2002). These findings suggest that there continues to be ambivalence and inconsistency about the most appropriate ways to address the alcohol and driving issue – even when a device such as an ignition interlock has proven its effectiveness.

For ignition interlocks to work, procedures must be put in place to insure that the devices are installed in an expeditious manner. Imposing penalties for failing to get the devices installed in an expeditious manner could address this issue. Currently, Michigan imposes a 3-month extension of the time before an offender may request another license appeal hearing for failing to report the device installation service.

Further, while interlocks have been shown to be effective, they are only effective to the extent that they are in use. Thus, more widespread and sustained use should have substantial impacts on impaired driving crashes. This is most easily achieved by increasing the length of the required use of the interlock. Alternatively, instead of forcing offenders to use the device for a predetermined amount of time, performance based criteria can be used (i.e., offenders must show that they no longer need the device to avoid impaired driving). Finally, efforts could be made to incentivize offenders to have the device installed, thereby increasing their use and in turn reducing rates of future impaired driving occurrences. For example, Vaos, Blackman, Tippets, and Marques (2001) found that when faced with the choice of house arrest or installation of ignition interlock device, about 67% of the offenders chose installation of the device.

Currently available ignition interlocks have anti-circumvention features that prevent activities such as having others blow into the ignition interlock, or using a balloon or compressed air to blow into the ignition interlock. By using pressure and temperature sensors, recording all events related to vehicle use, and using running retests, many of the ways offenders have tried to circumvent ignition interlocks in the past have since been thwarted.

RESPONSIBLE ALCOHOL PRACTICES

Effectiveness: Medium **Cost:** Medium **Implementation Issues:** Medium

Overview

Responsible alcohol practices include beverage service (e.g., server training), minimum drinking age 21 (MDA-21) enforcement (e.g., vendor compliance checks to ensure youth cannot purchase alcohol or laws that punish underage drinking), and programs within a given community or school. Each of these countermeasures can help address the problem of underage drinking, as well as drinking and driving. One community-based program, called Communities Mobilizing for Change on Alcohol (CMCA), evaluates specific communities and creates a plan of action that incorporates the most relevant responsible alcohol practices for that community.

Effectiveness

Server training is a multi-faceted approach to reduce drinking and driving. It can include how to recognize an intoxicated patron, limiting cheap drinks, and designated driver programs. For it to work, server training must be backed by support from management and owners. Research has shown that extensive server training definitely has the potential to reduce drinking and driving, because it limits the source of intoxication (Shults et al., 2001). When server training programs lack support, they are unlikely to result in the reduction of occurrences of alcohol-impaired driving. Further, although these findings are promising, they may not apply to larger, community-wide server training programs for which evidence is insufficient (Task Force on Community Preventive Services, 2001)

Other efforts to reduce underage drinking can be very effective. For example, compliance checks of vendors that are well-publicized and occur often are one way to make it difficult for teens to obtain alcohol. A review by Elder et al. (2007) of eight studies found that compliance checks reduce underage sales by about 42%. When several such tactics are combined, as in the CMCA program, a community can effectively improve several problem areas. For example, in a study by Wagenaar, Zobek, Williams, & Hingson (2000) that evaluated the CMCA program, several parts of the community were affected. Merchants were more likely to check IDs after the intervention, youth were less likely to try to purchase alcohol, law enforcement were perceived as more likely to write citations for illegal behavior, and people that could buy alcohol were less likely to do so for underage individuals. Here again, a multi-pronged approach to the problem helps to close down previously-available options for teen drinkers. It also symbolizes the effort and importance attached to underage drinking within the community.

However, not all community-based or school-based programs are effective, and the specific needs of a given population should be examined before a program is chosen. For example, alcohol-related school programs are very inconsistent in their effects and often have no effect. Cultural factors may be an important issue to consider here. For example, if drinking is associated with certain high-status, popular teens within a school community, other teens may

aspire to be like them and engage in drinking as well. Combating such a situation necessitates strong, positive role models within the school community – both teen and faculty/administration – so that alternative (non-drinking) behaviors are encouraged and rewarded. Family members also can be an important part of the effort to reduce underage drinking – particularly when family expectations map onto those of school and community.

Costs

Because of the variability of the above countermeasures, the costs associated can also vary greatly. Federal and state funding is often available, however.

Implementation Issues

Compliance can be an issue with responsible alcohol practices. Since communities often need participation from people whose business interests are not in favor of reducing alcohol sales (such as alcohol retailers and restaurant owners), compliance can prove difficult. Strong and consistent community support is important and requires sustained efforts in raising awareness of the problem, creating policies that discourage (or at least reduce) its impact, and following up to ensure that the problem is handled before it spirals out of control.

ZERO-TOLERANCE LAWS

Effectiveness: Medium **Cost:** Medium **Implementation Issues:** Medium

Overview

Zero tolerance laws make it illegal for drivers under age 21 to have measurable amounts of alcohol in their blood, resulting in immediate license suspension and fines. Often, these laws set the maximum BAC for drivers less than 21 at .02. This low BAC threshold guarantees that underage alcohol consumption of any quantity (greater than such negligible alcohol sources as mouthwash or communion wine) can be penalized.

In Michigan, a zero tolerance law was implemented in November of 2004. Michigan's zero tolerance law prohibits anyone under the age of 21 years from operating a motor vehicle with a BAC in excess of 0.02 but less than 0.08. The penalties for a first offense zero tolerance violation is limited to community service for not more than 360 hours and a fine of not more than $250. There is no possibility of imprisonment for a first offense. A second offense within seven years carries a maximum of 60 days community service, a fine of not more than $500 and/or imprisonment for not more than 93 days.

Effectiveness

Zero tolerance laws have been in effect in the U.S. since the early 1990s. An early study of 12 states that passed zero tolerance laws reported a 20 % reduction in the proportion of fatal crashes that were single-vehicle nighttime events (crashes likely to involve alcohol impairment) among drivers ages 15-20 years (Hingson, Heeren, & Winter, 1998). A number of other studies have found that zero tolerance laws reduce alcohol-related crashes, fatalities, and injuries (Jones & Lacey, 2001; Voas, Tippetts, & Fell, 2003). Liang and Huang (2008) investigated the effects of zero tolerance laws on college students and determined that the laws led to lower rates of drinking and driving. Yet another study found that zero tolerance laws can have a drastic impact on saving lives. For example, it was determined that the two primary underage drinking laws (which include zero-tolerance laws and laws regulating the purchase and possession of alcohol) currently save about 732 lives per year (Fell, Fisher, Voas, Blackman, & Tippetts, 2009).

Costs

Zero tolerance laws are only effective if enforced, and enforcement efforts have specific cost requirements (e.g., training, equipment). However, zero tolerance laws can be enforced during regular patrol or existing alcohol enforcement efforts (i.e., public campaigns, saturation patrols).

Implementation Issues

The degree of difficulty depends on a State's laws regarding probable cause for DWI arrest and BAC testing. Preliminary breath test devices and passive alcohol sensors can greatly aid in determining if an underage individual has consumed alcohol. There are also extra issues that arise when detaining a juvenile and extra care must be taken by law enforcement not to violate laws protecting juveniles.

Michigan already has an implemented zero tolerance law. However, it should be noted that in addition to the law, public awareness campaigns can dramatically increase the effectiveness of the law. For example, while on average Maryland experienced an 11 % statewide reduction in young drivers who "had been drinking" and crashed following the implementation of its 0.02% zero tolerance law, comparatively six counties where a special public education campaign was implemented saw a reduction of nearly 50% (Blomberg, 1992).

VEHICLE IMPOUNDMENT, IMMOBILIZATION, AND FORFEITURE

Effectiveness: Medium **Cost:** Medium **Implementation Issues:** Medium

Overview

Impoundment, immobilization, and forfeiture are commonly used in conjunction with alcohol-impaired driving. Vehicle impoundment is the temporary seizure of an offender's vehicle. When a vehicle is immobilized, an offender may be ordered to have his/her vehicle immobilized and return proof of immobilization to the court. In vehicle forfeiture, the offender's vehicle may be seized and sold at auction. In Michigan, all three approaches are used.

Effectiveness

Several studies have shown that vehicle impoundment, immobilization, and forfeiture is effective at reducing recidivism rates for driving with a suspended license (DWS), driving while unlicensed (DWU), and alcohol-impaired driving (Beirness, Simpson, Mayhew, & Jonah, 1997; Voas, Tippetts, & Taylor, 1998). For example, California's impoundment and forfeiture laws have been found to reduce subsequent DWS/DWU convictions by 23.8% for first offenders and 34.2% for repeat offenders (DeYoung, 1997). It should be noted that the mere threat of impoundment does not deter driving after suspension or revocation: a vehicle must actually be impounded to influence a driver's behavior (DeYoung, 2000).

Costs

Storing seized vehicles can be expensive—upwards of $20 per day. Some vehicle owners decide not to pay the fees for old or inexpensive vehicles and leave the vehicles unclaimed in storage. Some states, such as California, use towing companies to seize the vehicles, and use the funds from drivers reclaiming the vehicle and the sale of unclaimed vehicles to pay for the program.

Implementation Issues

An obvious issue associated with vehicle impoundment and forfeiture is that people rely on vehicles for everyday life. Seizing a vehicle can disrupt more lives than the offender's. Vehicles are also expensive and taking expensive property may likely lead to very upset citizens. Finally, administrative issues can arise if someone other than the offender owns the vehicle. Some states combat this by having the owner of the vehicle sign an affidavit ensuring the offender will not drive the vehicle during suspension (NHTSA, 2008a).

AUTOMATIC LICENSE SUSPENSION OR REVOCATION

Effectiveness: High **Cost:** Medium **Implementation Issues:** Medium

Overview

With automatic license suspension (ALS, temporary removal of an offender's license) or revocation (ALR, permanent removal of an offenders license from which one must reapply) an offender does not have to be convicted of anything to have his/her license removed. It allows a license issuing agency or law enforcement official to revoke a driver's license if a driver fails or refuses to take a BAC test. Often, the arresting police officer will confiscate the driver's license at the time of the arrest. The offender may then be provided with a temporary driver's license and scheduled for a future court appearance. In some states, drivers may also apply for hardship licenses that allow them to get to and from work. It is recommended that ALR laws include a minimum license suspension of 90 days; however, reinstatement of driving privileges is not always automatic.

The process of license revocation or suspension varies across states significantly in a number of ways. First, the length of suspension can vary, as well as the length of time a temporary license is valid. Further, some states, but not all, issue hardship licenses so that offenders may drive to work.

The suspension and revocation penalties imposed by the State of Michigan vary depending on the severity of the offense (e.g., fatality), but most penalties include a suspension of at least 90 days for the first offense and denial/revocation for future offenses. Further information on penalties associated with the varying offenses can be found at http://www.michigan.gov/documents/licens~1_20407_7.PDF.

Effectiveness

ALS laws have been shown to reduce the number of drivers involved in fatal crashes by about 9% during nighttime hours prior to their implementation (Zador et al., 1988). Other studies have shown that license suspension either alone or in combination with other laws result in alcohol-impaired fatal crash reductions of 5-6% (Wagenaar & Maldonado-Molina, 2007).

Regarding hardship licenses, studies have shown that the loss of a license rarely has an impact on a person's ability to maintain employment. Drivers have stated that they would still be able to get to work even if they could not drive. Studies also have shown that employment stability or income is rarely impacted for alcohol-impaired driving offenders (Knoebel & Ross, 1997).

Finally, research shows that the impaired driving crashes and other violations continue to be reduced after the suspension period ends (Voas, Tippetts, & Taylor, 2000).

Costs

License suspension or revocation require the establishment and maintenance of a system to coordinate the process and as a result they can be expensive. However, many of the costs can be recovered through fees or other charges/fines (NHTSA, 2008b). Examples of fees often charged to help recoup some of these costs include a reinstatement fee to receive a new license at the end of the suspension period. These fees, which are paid by offenders, can cover or exceed the cost of the program.

Implementation Issues

In the past, difficulties in conducting administrative hearings in some states have inhibited the use of ALS laws. Examples of these difficulties include case backlogs, scheduling conflicts that make it difficult for law enforcement officers to appear at hearings, and the use of technicalities to rescind the license suspension.

HIGH BAC LAWS

Effectiveness: Medium **Cost:** Low **Implementation Issues:** Low

Overview

Many states have started to implement increased penalties for offenders with excessively high BAC levels. The level set typically ranges anywhere from 0.15 to 0.17 BAC. Penalties are often enhanced for offenders of a high BAC law (e.g., increased length of license suspension, increased fine).

Michigan recently implemented a new high BAC law (on October 31, 2010). Michigan's new high BAC drunk driving law imposes enhanced penalties for first-time drivers convicted of operating with a BAC of 0.17 or higher. Some of the enhanced penalties offenders could face include up to 180 days in jail (increased from 93 days), a fine of $200 but not more than $700 (increased from $100 but not more than $500), and a one-year license suspension with restrictions permitted after 45 days (increased from six-month license suspension with restrictions permitted after 30 days).

High BAC laws can vary across both the limit set (e.g., 0.15 BAC for Indiana vs. 0.20 BAC for Minnesota) and on the enhanced penalties themselves. For example, in addition to the enhanced penalties for Michigan described above, other states have additional enhanced penalties that can include treatment for alcohol problems, close monitoring or home confinement, installation of an ignition interlock, and vehicle or license plate sanctions.

Effectiveness

The effectiveness of high BAC laws is relatively unknown. To date, only evaluations of Minnesota's high BAC law has been conducted (McCartt and Northrup, 2004). Minnesota has a relatively high BAC threshold as part of its high BAC law, 0.20, with even more enhanced penalties (e.g., more severe pre-conviction administrative sanctions and post-conviction court sanctions that are mandatory, substantial, and applicable to both first and subsequent offenses including mandatory minimum jail sentence, a doubling of the license revocation sanctions; a pre-conviction administrative license plate impoundment, and stiffer fines). In that study, the researchers found that the implementation of Minnesota's high BAC law initially resulted in a decrease in rates of recidivism, but that the decrease leveled off over time. They also found that BAC test refusal rates declined for first time offenders.

Because the implementation of Michigan's high BAC law is so recent, an evaluation of its effectiveness is currently not possible. However, in the near future a study should be conducted to determine the effect of the law on high BAC driving rates.

Costs

The only costs associated with high BAC laws are in the extra effort needed to impose more enhanced penalties.

Implementation Issues

To date, no significant concerns have been expressed regarding the implementation of a high BAC law, in Michigan or in other states. Thus, while Michigan recently implemented a high BAC law, any future changes to Michigan's law should not be met with significant resistance. There are no other major issues preventing implementation of a change in Michigan's high BAC law.

DESIGNATED DRIVER PROGRAMS

Effectiveness: Low **Cost:** Low to Medium **Implementation Issues:** High

Overview

The most common definition of a designated driver (DD) requires that the DD fits into these three criteria. First, the driver must abstain from alcohol. Too often, a "designated driver" will consume alcohol but try not to drink enough to legally be considered driving while alcohol-impaired. Second, as the term designated implies, the DD, should be assigned before anyone in the group starts drinking. Finally, the DD should be responsible for driving all the group members to their homes or safe location.

A number of different approaches to increasing DD behaviors have been conducted nationally and in the State of Michigan. These are primarily population-based media campaigns or youth education programs. Population-wide promotion campaigns use mass media and other communication channels to promote use. Additional programs have also tried to establish incentive based programs in drinking establishments. Incentive programs offer free incentives to encourage customers of drinking establishments to act as designated drivers. Examples of free incentive programs include free soft drinks, nonalcoholic drinks, nonalcoholic beer, food, or free admission. Displays in the drinking establishment are the most typical method of informing customers about the availability of incentives.

Effectiveness

Data regarding the effectiveness of the DD programs is minimal and doesn't provide strong insight in to their effectiveness. Ditter et al. (2005) completed a comprehensive review of both population-based campaigns and incentive programs based in drinking establishments. Unfortunately only one study of population-based media campaigns was found to have analyzed the effectiveness of such campaigns. That study showed that selection of a DD before consuming alcohol as part of a group increased by 13%, but actual incidence of alcohol-impaired driving remained unchanged.

Eight studies analyzing the effects of incentive based programs in drinking establishments were reviewed. The results of the meta-analysis showed that the selection of designated drivers increased and actual incidence of alcohol-impaired driving decreased.

Costs

DD programs are costly to the extent that publicity campaigns are executed (see next section on Mass Media Campaigns).

Implementation Issues

Participation by establishments that serve alcohol is difficult to obtain and/or enforce/monitor. Considering that the incentive programs offer free food or non-alcoholic beverages to customers, some establishments may be concerned about loss of revenue. Indeed, it is possible that patrons

could “game the system” by claiming to be a DD when they have no intention of doing so. This could be overcome by helping the establishments understand the costs associated with allowing a patron to leave their establishment and driving while alcohol-impaired. Thus, a public service campaign or educational training may be necessary.

Also, as previously mentioned, information regarding the incentive programs is often found inside the establishment. Would participation increase if the incentive program information was located in a more public place (even simply outside the establishment)?

MASS MEDIA CAMPAIGNS

Effectiveness: High **Cost:** Medium **Implementation Issues:** Low

Overview

Common mass media campaign methods include attempts to instill a fear of injury to one self, others, or property, a fear of being arrested, and characterization of alcohol-impaired drivers as irresponsible and dangerous to others. Mass media campaigns are usually aimed at persuading individuals either to avoid drinking and driving or to prevent others from doing so. Examples of mass media campaigns (which are often accompanied by other BCMs such as increased saturation patrols) include the "Over the Limit. Under Arrest" programs and the "You Drink. You Drive. You Lose". Other example includes a series of commercials produced by Mothers Against Drunk Driving (MADD) that show video of recent victims.

Effectiveness

Elder et al. (2004) conducted a systematic review of eight studies that analyzed the effectiveness of various mass media campaigns on the reduction of alcohol-impaired driving. While there were some difference between the different campaigns (e.g., some focused on legal consequences while others focused on social responsibilities), they all had several aspects in common:

- They all had a theoretical framework in communications research.
- All had pre-tested the messages before the campaign.
- They all had relatively high levels of audience exposure to the message, mostly through paid advertising.

It should be noted that all of the campaigns were implemented in collaboration with other BCM efforts.

The results of the analysis showed that as a result of implementing the mass media campaigns alcohol-related crashes decrease by an average of 13% and injury causing alcohol-related crashes decreased an average of 10% compared to rates prior to their implementation. There were no differences as a function of the type of campaign conducted (e.g., legal consequences vs. social responsibilities).

Regarding the effectiveness of mass media campaigns in Michigan, NHTSA conducted an evaluation aimed at assessing the efficacy of mass media campaigns on the incidence of alcohol-impaired driving (the same study was conducted in six other states). Michigan's mass media campaign was coupled with increased saturations patrols and community partnerships. The media campaigns primarily focused on DWI enforcement (e.g., increased threat of arrest and the possibility of drivers forfeiting their vehicles, losing their driver licenses, and paying fines) and targeted male drivers 18 to 34 years old. Television and radio ads were used in the campaign.

Eighty to 85% of the State was covered as part of the campaign. As a result of implementing the BCMs Michigan saw significant reductions in alcohol-impaired driving fatalities and was estimated to have saved 57 lives. As a result of this program, it was recommended that state impaired driving enforcement programs in Michigan incorporate (a) highly visible saturation patrols conducted routinely throughout the year along with mobilized crackdowns (at least three per year) and (b) intensive publicity coverage of the enforcement activities, including paid advertising.

Costs

Mass media campaigns can be expensive because of the costs associated with planning, production, and air time, mass media campaigns can be expensive. This can be offset through partnerships with other organizations or through grants or other available funds. Further, it is important to note that a significant portion of the costs are up-front, initial costs associated with the production of the campaign itself. States and municipalities also may decide to incorporate such mass media campaigns into their budgets without significant offsets. Mass media campaigns can be used to highlight and strengthen views and expectations regarding drunk driving, and play a role in creating a distinctive local culture.

Implementation Issues

Mass media campaigns are currently implemented with regular frequency. Thus, implementation of a new campaign should not be difficult. One thing to consider for future implementations is the medium through which the campaigns are pushed. With technology changing at such a fast pace, attention should be paid towards using alternative media (e.g., social network sites) that may prove to be effective in the future.

COURT MONITORING

Effectiveness: Low **Cost:** Low **Implementation Issues:** High

Overview

A court monitoring program consists of the observation and tracking of DWI court and other administrative process involved in alcohol-impaired driving cases. The purpose of the program is to gauge and help insure that courts are conducting business appropriately and as efficient as possible. The data tracked includes plea agreements, sanctions imposed and other forms of adjudication. Court monitoring is usually conducted by private organizations.

Effectiveness

Limited studies have shown that the practice of court monitoring increases the levels and frequencies of adjudication in alcohol-impaired driving cases (Probst et al., 1987, Shinar, 1992). However, the effect on actual occurrences of impaired driving recidivism is not well known

Costs

Court monitoring can be relatively inexpensive, if the monitors are low-cost employees or even volunteers.

Implementation Issues

The biggest obstacle is in finding people to serve as court monitors. Often, they are compensated financially at a low rate, or even asked to volunteer for free. While people are often well-intentioned inititally, their participation as a court monitor often wanes over time.

REPEAT OFFENDER LAWS

Effectiveness: Medium Cost: Low Implementation Issues: Low

Overview

In Michigan, a repeat offender is defined as someone who has had two or more alcohol-related convictions within seven years, or three or more alcohol-related convictions within 10 years. Sanctions under the repeat offender laws include additional driver license suspensions or revocations, license plate confiscation, vehicle immobilization or forfeiture, registration denial, the use of ignition interlock devices, and mandatory substance abuse treatment. Repeat offenders who cause an crash resulting in a long-term injury or death are charged with a felony and face thousands of dollars in fines and years in jail in addition to other penalties. In addition to the actions described above, some states have also implemented a reduced BAC limit for repeat offenders (e.g., 0.02).

Effectiveness

Eby et al. (2002) found that Michigan's repeat offender laws are effective at reducing alcohol-impaired driving, but they have not had a significant effect on driving with a suspended or revoked license. Research has also shown that lower BAC limits for repeat offenders has contributed to a reduction in the percentage repeat offenders (Hingson, Heeren, and Winter, 1998; Jones and Rodriguez-Iglesias, 2004).

Costs

Few costs are associated with repeat offender laws except to the extent that they increase the resources required to enforce adjudication.

Implementation Issues

Michigan already has repeat offender laws in place. Any change to the law in attempts to reduce impaired driving is not likely to meet resistance from the general public. The only implementation is simply passing changes to the law through legislative processes.

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YOUNG DRIVERS

Overview

The leading cause of death for teenagers in the United States is motor vehicle crashes. In 2009, 2,336 drivers were killed who were age 15 to 20 years and another 196,000 were injured in motor vehicle crashes (NHTSA, 2011). In 2007, 6.4% of all licensed drivers in the United States were age 15 to 20 years. However, drivers age 15 to 20 years old were involved in 11% of fatal crashes and 14% of all crashes[2].

Out of all the age groups, young drivers have the highest involvement in fatal crashes. In 2008, the crash rate per mile driven for drivers aged 16 to 19 years was four times higher than for adult drivers (IIHS, 2009). Further, drivers aged 16 to 20 years are approximately twice as likely to be involved in a fatal crash compared to adult drivers (see Figure 2). In addition, the crash rate per mile driven for 16-year-olds was twice as high when compared to drivers age 18 and 19 years old.

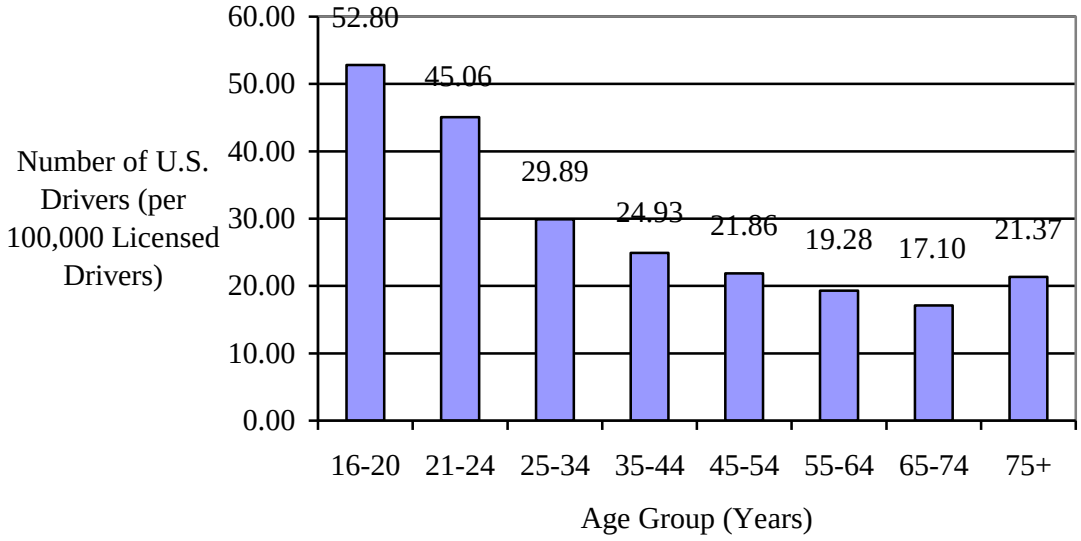

Figure 2. 2007 U.S. Drivers Involved in Fatal Crashes per 100,000 Licensed Drivers (NHTSA, 2009).

The high crash rates for teenagers are largely due to their driving inexperience combined with their immaturity (IIHS, 2009; NHTSA, 2011). Inexperience causes many teenagers to devote most of their attention to the mechanics of driving, and safety often becomes a secondary

[2] The definition of a young driver varies across the sources referenced in this report. However, this does not minimize the conclusion that drivers of a younger age are at greater risk for fatal and injury-related crashes than older drivers.

consideration. Teenagers do not have experience in recognizing potentially hazardous/risky situations or controlling and reacting appropriately with their vehicles when such situations arise.

Inexperience and immaturity often play a critical role in certain situations (IIHS, 2009; NHTSA, 2011). Driving at night is more dangerous and difficult for everyone, but particularly for novice drivers who have less experience driving at night compared to daytime driving (Williams, 2003). Traveling with teenage passengers can encourage young drivers to take risks and distract them. Furthermore, cell phone use while driving increases the risk of a crash, and teenagers are more likely to use cell phones compared to older drivers (Lee, 2007).

Forty four states have implemented a Graduated Driver Licensing (GDL) program to address the immaturity and inexperience of young drivers (IIHS, 2011). GDL programs place restrictions (e.g., nighttime, passenger) on young drivers so that they may gain driving experience in less risky situations. GDL also can increase the minimum age of full licensure and help parents manage their teenage drivers. The effectiveness of GDL programs in reducing the number of young drivers involved in crashes has been widely shown (Chen, Baker, & Li, 2006; Foss, Feaganes, & Rodgman, 2001; Williams, 2007; Williams, Chaudhary, & Tison, 2010).

In the State of Michigan, teen/young adult drivers (age 16-24 years) represented 14.1% of the licensed drivers in 2009 (Michigan Traffic Crash Facts, 2009). The number of teen/young adult drivers in all crashes has decreased by 38.4% since 2000 (see Figure 3). Their involvement in fatal crashes decreased 50.7% during the same time period. However, as of 2010 teen/young adult drivers were involved in 21.0% of fatal crashes and represented 25.2% of all occupant injuries in crashes (see www.michigantrafficcrashfacts.org/doc/2010/occ_1.pdf).

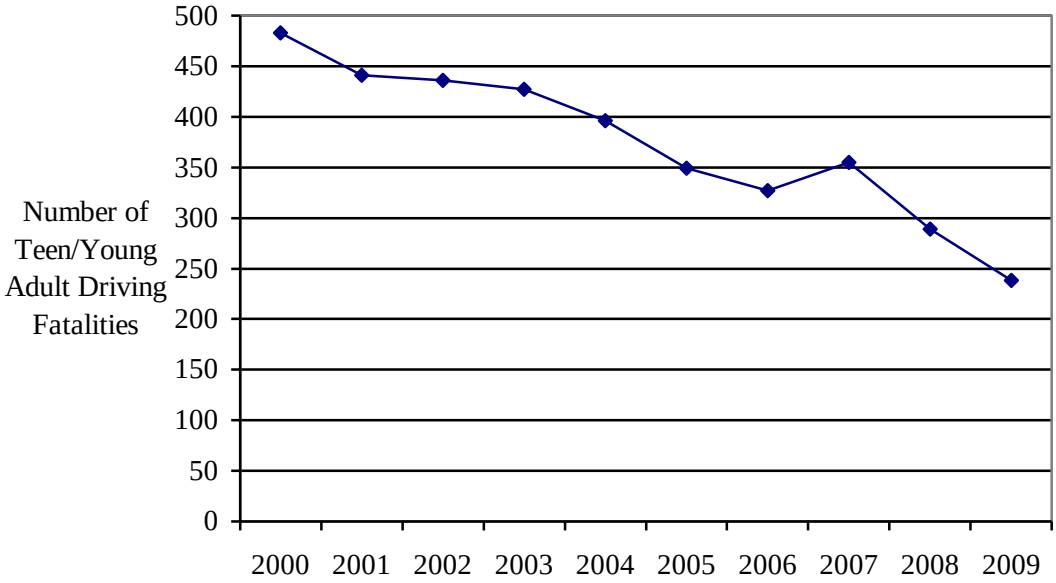

Figure 3. 2000 - 2009 State of Michigan teen/young adult driving fatalities. (2009 Michigan Traffic Crash Facts, 2010)

Table of Summary Ratings. Table 4 contains an estimate of each countermeasure's effectiveness, cost, and issues for implementation. The ratings follow the system previously described. The ratings for zero tolerance laws were also included in this table because of their relevance to young drivers. However, the review of zero tolerance laws is in the alcohol impaired section.

Table 4. Estimates of each youth driver countermeasure for effectiveness, cost, and implementation issues.

Countermeasure	Effectiveness	Cost	Implementation Issues
Graduated Driver Licensing	High	Low	Low
Driver Education	Low	Medium	Medium
Parent Involvement	Medium	Low	Medium
Licensing Age	Medium	Low	Medium
Nighttime Driving Restrictions	High	Medium	Low
Passenger Driving Restrictions	High	Medium	Low
Seat Belt Laws & Youths	Medium	Low	Low
Cell Phone Use	Medium	Low	Low
Youth Programs	Medium	Medium	Low
School Education Programs	Low	Low	Medium

GRADUATED DRIVER LICENSING

Effectiveness: High **Cost:** Low **Implementation Issues:** Low

Note: This review is provided as a high-level analysis of GDL programs. More specific discussion of particular facets of the programs (e.g., nighttime driving restrictions) is addressed later in the section.

Overview

44 states have now implemented a Graduated Driver Licensing (GDL) program for teenage drivers younger than 18 years old. There are several stages to most GDL programs which include a learner stage, an intermediate stage, and finally an unrestricted stage (IIHS, 2011).

Teenagers qualify to enter the GDL learner stage between 14 to 16 years-of-age, which includes either a minimum amount of supervised driving with a parent, driver instructor, or both (IIHS, 2011). Once a teenage driver has completed the learner stage requirements, they are eligible to enter the intermediate stage with restrictions on driving while unsupervised. The restrictions include either a ban on night driving, a limit on the number of teenage and young adult passengers (ages ranging from under 18 to 21 years), or both. Teenage drivers who have a good driving record can have the restrictions lifted between the ages 16 years, 6 months and 18 years old depending on the state.

The GDL program in Michigan was implemented on April 1, 1997, and consists of two segments of driver education and three levels of licensing (Michigan's Graduated Driver Licensing: A Guide for Parents, 2011). A teen must be 14 years, 9 months old to enroll in a Segment 1 driver education class. There are 24 hours of classroom instruction, 6 hours of behind the wheel instruction in a specialized driver education vehicle, and 4 hours of observation time as a passenger in a training vehicle during the Segment 1 class. Upon completion of the Segment 1 class, teens may apply to receive a Level 1 Learner's License from a branch office of the Secretary of State with written permission from a parent/legal guardian.

The Level 1 Learner's License allows a teenager to drive while supervised by a licensed parent/legal guardian or a designated licensed adult age 21 years or older who is sitting in the front seat (Michigan's Graduated Driver Licensing: A Guide for Parents, 2011). In order to enroll for the Segment 2 driver education class, a teen must complete at least 30 hours of supervised driving including 2 hours of night driving (out of the required 50 supervised hours of driving including 10 hours of night driving). A teenager must also have held a Level 1 License for at least 90 consecutive days.

Teaching defensive driving is the primary goal of the 6 hours of classroom instruction provided during the Segment 2 driver education class (Michigan's Graduated Driver Licensing: A Guide for Parents, 2011). To apply and receive a Level 2 Intermediate License a teenager must be at least 16 years old, possess a Level 1 License for at least 6 months, complete Segment 1 and 2 driver education courses, and pass a driving skills test. A teen must also be violation and suspension free, and have no at-fault crashes in the 90 days prior to applying for a Level 2 Intermediate License, and have completed a minimum of 50 hours of supervised driving, including 10 hours at night.

A Level 2 Intermediate License allows a teen to drive without supervision. However, a teen must drive with a designated licensed adult over age 21 years between 10 p.m. and 5 a.m., unless driving to and from employment, and no more than one passenger younger than 21 years old is allowed in the vehicle. The Level 3 License or Operator License is automatically mailed when a teen is at least 17 years old, has held a Level 2 License for at least 6 months, is suspension and violation free, and has no at fault crashes for 12 consecutive months. The GDL program ends at the age of 18 and the night driving/passenger restrictions are lifted if they are still present.

Effectiveness

There have been several evaluations of GDL programs on a national scale. Chen, Baker, and Li (2006) reported an 11% overall reduction in fatal crashes for 16 year old drivers between 1994 and 2004 in states that have implemented a GDL program compared to states that did not currently have a GDL program. The overall percentage of crashes at night by 16 year olds has also been substantially reduced after the implementation of GDL nighttime driving restrictions, including a 59% reduction in total nighttime crashes in Michigan (Williams, 2007).

GDL evaluations have been completed for several other states as well including New Jersey, North Carolina, and Oregon. Williams, Chaudhary, and Tison (2010) found a reduction of crash rates for 17 year old drivers of 16% on all crashes (25% on fatal crashes), and a reduction of total crashes for 18 year old drivers by 10% (4% on fatal crashes) after the implementation of the New Jersey GDL program. The crash rates of 16 year old drivers in North Carolina decreased by 27% after implementing a GDL program (Foss, Feaganes, & Rodgman, 2001). Similarly, Oregon observed a significant reduction in the number of crashes involving 16 and 17 year old drivers after their GDL program implementation in 2000 (NHTSA, 2007).

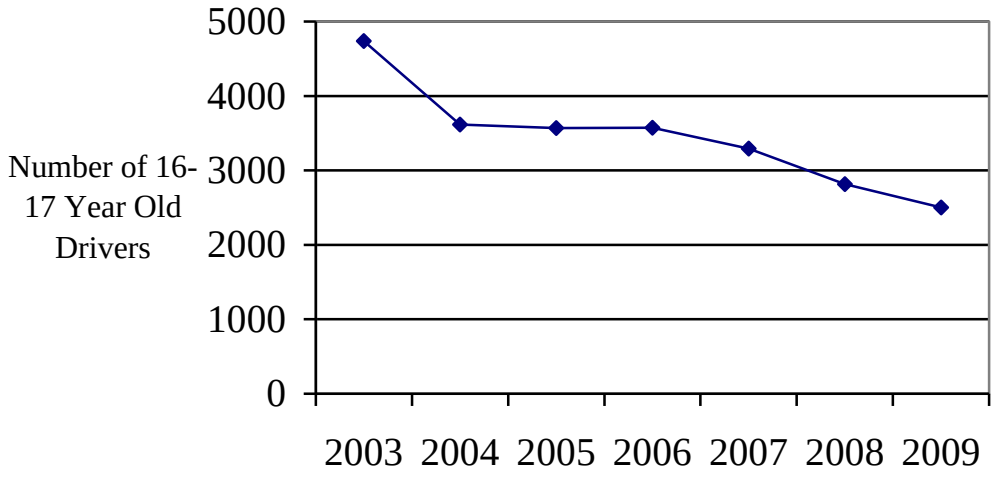

Figure 4. 2003 - 2009 State of Oregon number of crashes involving 16-17 year old drivers[3].

Cost

The only costs associated with GDL programs are for the enforcement of restrictions, the Level 1 license, and Level 3 license. Restrictions for the Level 1 and Level 2 licenses can be enforced during regular patrols. Currently the State of Michigan does not charge a fee for obtaining a Level 1 or Level 3 license. Michigan charges $25 for obtaining a Level 2 license and $18 for all license renewals except for the initial Level 3 license.

Implementation Issues

Michigan already has implemented a GDL program. Parents are an integral part of ensuring the success of a GDL program (Michigan's Graduated Driver Licensing: A Guide for Parents, 2011). It is important that parents understand, follow, and help enforce the laws and guidelines of the GDL program as they have the greatest influence over their teenager's driving behavior.

[3] (2003 Oregon Traffic Crash Summary, 2004; 2004 Oregon Traffic Crash Summary, 2005; 2005 Oregon Traffic Crash Summary, 2006; 2006 Oregon Traffic Crash Summary, 2007; 2007 Oregon Traffic Crash Summary, 2008; 2008 Oregon Traffic Crash Summary, 2009; 2009 Oregon Traffic Crash Summary, 2010)

DRIVER EDUCATION

Effectiveness: Low **Cost:** Medium **Implementation Issues:** Medium

Overview

Driver education is required by 33 states prior to licensure for teenagers younger than the age of 18 years old (NHTSA, 2011). Many states require 30 hours of classroom instruction and 6 hours of behind the wheel practice. Michigan requires that all teenagers younger than 18 years old complete two segments of driver education (Michigan's Graduated Driver Licensing: A Guide for Parents, 2011). The teen must be at least 14 years, 9 months old and have parent or legal guardian permission to enroll in Segment 1 Driver Education. The Segment 1 course consists of 24 hours of classroom instruction, 6 hours of behind the wheel driving experience, and 4 hours of observation time in a training vehicle. The purpose of the Segment 1 class is to teach teens traffic and road laws.

The requirements for enrolling in Michigan's Segment 2 Driver Education course are a minimum of 30 hours of supervised driving time, including 2 hours of night driving, and holding a valid Level 1 License for at least 3 consecutive months (Michigan's Graduated Driver Licensing: A Guide for Parents, 2011). The Segment 2 course consists of 6 hours of classroom driver education instruction. No behind the wheel instruction is provided during the Segment 2 course. The Segment 2 course emphasizes the importance of risk awareness while driving.

Effectiveness

Overall, studies and evaluations of driver education across the United States have found no long term reduction in crash rates for novice drivers (Compton & Ellison-Potter, 2008; NHTSA, 2011; Robertson & Zador, 1978; Williams & Ferguson, 2004; Williams, Preusser, & Ledingham, 2009). Some states offer incentives for novice drivers to enroll in driver education by lowering the licensing age or reducing the number of supervised driving hours upon successful completion of a driver education program (IIHS, 2011). Williams, Preusser, and Ledingham (2009) found earlier licensing upon completion of driver education can lead to an increased number of injuries and crashes among novice drivers. Traditional driver education programs are taught over short periods of time, and a majority of the time is spent teaching basic vehicle handling skills. Only a minimal amount of time is spent teaching safe driving skills.

In contrast, one study conducted in Oregon determined that 16 to 19 year old drivers who completed a formal driver education course had a crash rate 11% to 21% lower than novice drivers who did not complete a driver education course (ADTSEA, 2005). NHTSA conducted a technical assessment of the driver education program in Oregon in 2010. NHTSA recommended Oregon increase the classroom hours for driver education from 30 hours to 45 hours, increase

behind the wheel instruction from 6 hours to 10 hours, increase in car observation from 6 hours to 10 hours, and require second stage education of at least 10 hours.

Pezoldt, Womack, and Morris (2007) conducted a study in Texas comparing parent taught driver education to commercial/public driver education programs. The study found that drivers who were parent-taught experience more traffic violations and more crashes, including more serious crashes, when compared to novice drivers who completed a commercial or public school driver education program. Parent-taught novice drivers also displayed poorer driving knowledge and driving skills at the end of formal driver education.

Cost

The cost for even a minimal driver education course with 30 hours of classroom instruction and 6 hours of behind the wheel instruction requires extensive funds (NHTSA, 2011). The costs for a driver education course include course instructors, course supplies, vehicle insurance, and gasoline. Students must also find time in their schedules for the classroom and behind the wheel instruction.

In 2004, Michigan eliminated the driver education fund which provided partial reimbursement for driver education courses offered at public schools (MSOS, 2011). Parents/legal guardians are responsible for paying for their teen to enroll in both the Segment 1 and Segment 2 courses. The cost for enrolling in a Segment 1 course is between $300 and $400, and the cost for enrolling in a Segment 2 course is between $40 and $50.

Implementation Issues

Developing a driver education course can take at least a year to plan and implement (NHTSA, 2011). Several other implementation issues include standardizing course materials for driver education courses and training driver education instructors.

PARENT INVOLVEMENT PROGRAMS

Effectiveness: Medium **Cost:** Low **Implementation Issues:** Medium

Overview

Parents are heavily relied upon to teach driving skills and supervise driving while their novice teenage drivers have a learner's permit (IIHS, 2011; NHTSA, 2011). Once a teenager has obtained an intermediate license, parents are in the best position to enforce GDL restrictions and impose additional restrictions. Many programs have been developed to assist novice drivers and parents understand the dangers of high risk situations. These programs usually have parents and novice drivers sign a written agreement that limits a teenager from driving under various high risk situations (e.g., drinking or texting while driving)..

One program that assists parents and novice drivers is the Checkpoint program developed by Simons-Morton and colleagues. The Checkpoints program consists of a written agreement, signed by parents and novice drivers, which limits a teenager from driving under various high risk situations (Simons-Morton, Hartos, Leaf, & Preusser, 2005). These situations include driving at night, in bad weather, or with other teenagers in the car. Videos and periodic newsletters inform parents of the risks that new drivers face and present the need for parents to limit teenagers from driving during risky conditions.

Michigan requires parental consent for teenagers to enroll in Segment 1 and Segment 2 driver education courses, and to obtain a Level 1, Level 2, and Level 3 license (Michigan's Graduated Driver Licensing: A Guide for Parents, 2011). Parents are also responsible for supervising 50 hours of driving, including 10 hours of nighttime driving, by their teen with a Level 1 license.

Effectiveness

The Checkpoints program has been evaluated in several states, including Connecticut (Simons-Morton, Hartos, & Leaf, 2002; Simons-Morton et al., 2005; Simons-Morton et al., 2006). Simons-Morton et al. (2005) found that the Checkpoints program in Connecticut modestly increased parent's restrictions on novice driving for up to 12 months after signing the written agreement. However, there was no difference in the number of crashes or violations for novice drivers who participated in the Checkpoints program compared to novice drivers who did not participate in the program (Simons-Morton, Hartos, Leaf, & Preusser, 2006).

The evaluations of programs designed to assist parents and novice drivers have not shown a reduction in teen driver crashes. However, programs like Checkpoints have increased the number of restrictions parents place on novice drivers. Simons-Morton (2007) reviewed several studies that showed fewer traffic violations and crashes when parents impose stricter driving limits on teenagers.

However, as discussed in the previous section, driver education by the parent(s) alone is not sufficient, and it can lead to increases in crashes and fatalities.

Cost

There are only minimal costs associated with programs that encourage parental involvement in the education and skill development of novice drivers. Most programs are available online for free or for a minimal price.

Implementation Issues

Most programs are available immediately and can be accessed online. The Checkpoints program is now available to the general public (http://www.saferdrivingforteens.org/). Follow through by the parents would appear to be the largest obstacle in achieving a high amount of parental involvement.

LICENSING AGE

Effectiveness: Medium **Cost:** Low **Implementation Issues:** Medium

Overview

The age a teenager is able to obtain a license to drive unsupervised varies from 14 years, 3 months in South Dakota to 17 years in New Jersey, with most States requiring a teen to be at least 16 years old (IIHS, 2011). All states, except North Dakota, have placed nighttime and/or passenger restrictions on drivers with an intermediate license. The length of the restricted license period varies by state from 3 months to 2 years.

Michigan allows teenagers to obtain an intermediate license at the age of 16, once they have successfully completed the requirements of the GDL program (Michigan's Graduated Driver Licensing: A Guide for Parents, 2011; IIHS, 2011). Teens with an intermediate license are restricted from driving alone, without a designated licensed adult over age 21, between 10 p.m. and 5 a.m., unless driving to and from employment, and no more than one passenger younger than 21 is allowed in the vehicle.

Effectiveness

The effectiveness of an older licensing age was demonstrated in a study conducted in New Jersey (Williams, Chaudhary, & Tison, 2010). New Jersey has set the age for obtaining an intermediate license at 17 years old, which is later than the other 49 States (IIHS, 2011). Williams, Chaudhary, and Tison (2010) found that the higher licensing age in New Jersey has significantly reduced the number of 16, 17, and 18 year olds involved in injury and fatal crashes. It appears that the strong GDL system has minimized the negative impact to crash rates that would otherwise be expected of inexperienced 17 year old New Jersey drivers. The New Jersey GDL program ends at the age of 19 years. GDL programs end at the age of 18 years in all the other States that have an implemented system.

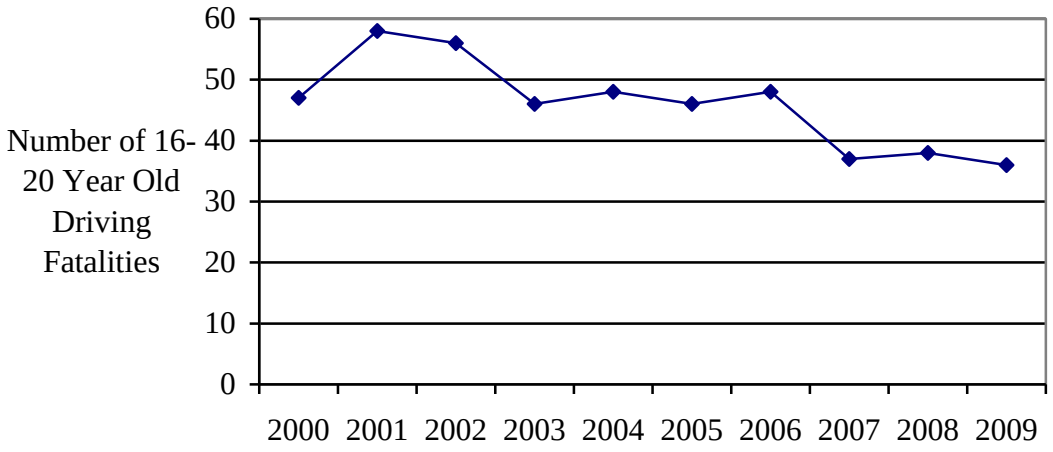

Figure 5. 2000 - 2009 State of New Jersey 16-20 year old driving fatalities[4].

Cost

Few costs are associated with increasing the licensing age, except that parents are required to continue "chauffeuring" their kids around to activities for up to an additional two years.

Implementation Issues

Many parents in Minnesota, North Carolina, and Rhode Island stated they favored a licensing age of 17 years or older from a safety standpoint (IIHS, 2008). However, pressure has not been placed on state governments to enact older licensing ages. Most teenagers are eager to obtain a license as soon as possible, and parents are disinclined to disappoint their kids. Parents may also believe that their own children will be safe drivers, and they are eager to stop chauffeuring their children to different activities. Several states, including Delaware, Florida, Georgia, and Massachusetts, have introduced legislation to increase the licensing age to 17 years old, yet none of these measures have been successful in gaining enough support to be enacted.

[4] (2004 Fatal Motor Vehicle Crash Comparative Data Report in the State of New Jersey, 2005; 2009 Fatal Motor Vehicle Crash Comparative Data Report, 2010)

NIGHTTIME DRIVING RESTRICTIONS

Effectiveness: High **Cost:** Medium **Implementation Issues:** Low

Overview

Nighttime driving restrictions for intermediate licensed drivers are part of the GDL programs in 48 States (IIHS, 2011; NHTSA, 2011). Teenage drivers with an intermediate license are not allowed to drive after a certain time at night (ranging from 6 p.m. to 1 a.m.) until a designated time the next morning (ranging from 4 a.m. to 6 a.m.).

Michigan has placed a nighttime driving restriction on all teenagers with an intermediate license (Michigan's Graduated Driver Licensing: A Guide for Parents, 2011; IIHS, 2011). Teens are not allowed to drive without a parent, legal guardian, or licensed adult over age 21 years between 10 p.m. and 5 a.m. unless traveling to or from employment. The nighttime driving restriction is lifted and an operator license is granted when a teen is at least 17 years old, has held a Level 2 License for at least 6 months, is suspension and violation free, and has no at fault crashes for 12 consecutive months. The GDL program ends at the age of 18 years old and the night driving restriction is lifted if it is still present.

Effectiveness

The effectiveness of nighttime for young drivers with intermediate licenses are well documented (Chen, Baker, & Li, 2006; Foss, Feaganes, & Rodgman, 2001; IIHS, 2006; McCart, Teoh, Fields, Braitman, & Hellinga, 2010; Mcknight & Peck, 2002; NHTSA, 2011; Williams et al., 2010). A study conducted by the IIHS found that the nighttime crash rates fell 27% for 16 year old California drivers after the implementation of a GDL program with nighttime driving restrictions (IIHS, 2006). Another study found an 18% reduction in fatal crashes with a nighttime driving restriction starting at 9 p.m. compared to no restriction, while there was only a 9% reduction in fatal crashes with a nighttime driving restriction that begins at 1 a.m. (McCartt et al., 2010).

After the implementation of Michigan's GDL program with nighttime driving restrictions there was a 26% reduction in crashes involving 16 year old drivers. (Shope, Molnar, Elliott, & Waller, 2001).

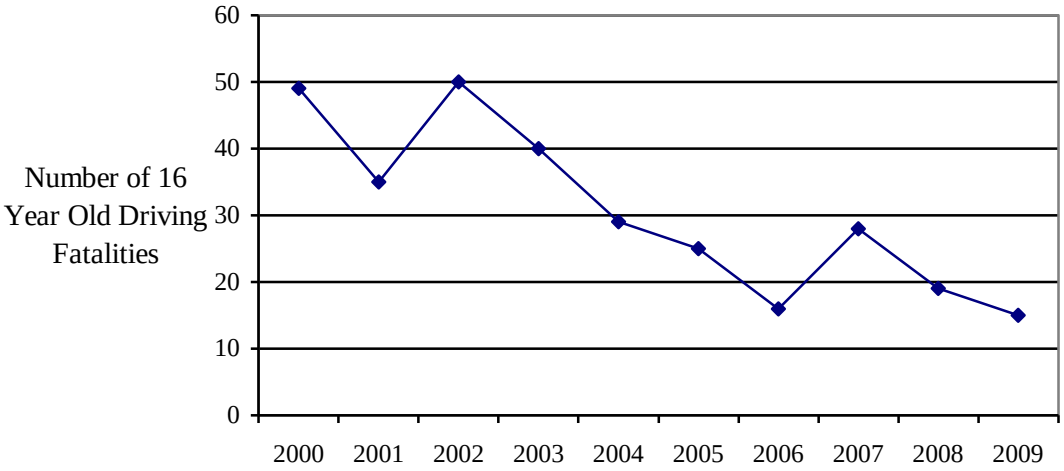

Figure 6. 2000 - 2009 State of Michigan 16 year old driving fatalities. (2009 Michigan Traffic Crash Facts, 2010)

Cost

The costs to implement or revise nighttime driving restrictions for intermediate licensed drivers are low. The greatest cost comes from notifying the public about the new restriction laws.

Implementation Issues

The only implementation issue for enacting a nighttime driving restriction for intermediate licensed drivers is the amount of time required to notify the public and implement the changes (NHTSA, 2011). It typically takes around 6 months to implement the changes and notify the public.

PASSENGER RESTRICTIONS

Effectiveness: High **Cost:** Medium **Implementation Issues:** Low

Overview

Currently, the GDL programs in 44 States place a restriction on the number of passengers allowed in a vehicle driven by a teenage driver with an intermediate license without adult supervision (IIHS, 2011; NHTSA, 2011). Depending on the State, intermediate licensed drivers are allowed to have 0 to 3 passengers who are under a certain age (18 to 21 years old), and the restrictions last between 6 months to 2 years.

In Michigan, intermediate licensed drivers are limited to having one passenger under the age of 21 unless they are driving to or from school or a school sanctioned event (Michigan's Graduated Driver Licensing: A Guide for Parents, 2011; IIHS, 2011). Immediate family members of the teen driver are exempt from the passenger restriction. The passenger restriction is lifted and an operator license is granted when a teen is at least 17 years old, has held a Level 2 License for at least 6 months, is suspension and violation free, and has no at fault crashes for 12 consecutive months. The GDL program ends at the age of 18 and the passenger restriction is lifted if it is still present.

Effectiveness

The effectiveness of passenger restrictions for young drivers with intermediate licenses are well documented (Chen, Baker, & Li, 2006; Foss, Feaganes, & Rodgman, 2001; Foss, 2009; IIHS, 2006; Mcknight & Peck, 2002; NHTSA, 2011; Williams et al., 2010). A study conducted by IIHS found that the crash rates with teenage passengers fell by 38% for 16 year old California drivers after the implementation of a GDL program with passenger restrictions (IIHS, 2006). Foss (2009) found a 32% decrease in 16 year old crashes involving multiple passengers after North Carolina enacted a passenger restriction on drivers with an intermediate license.

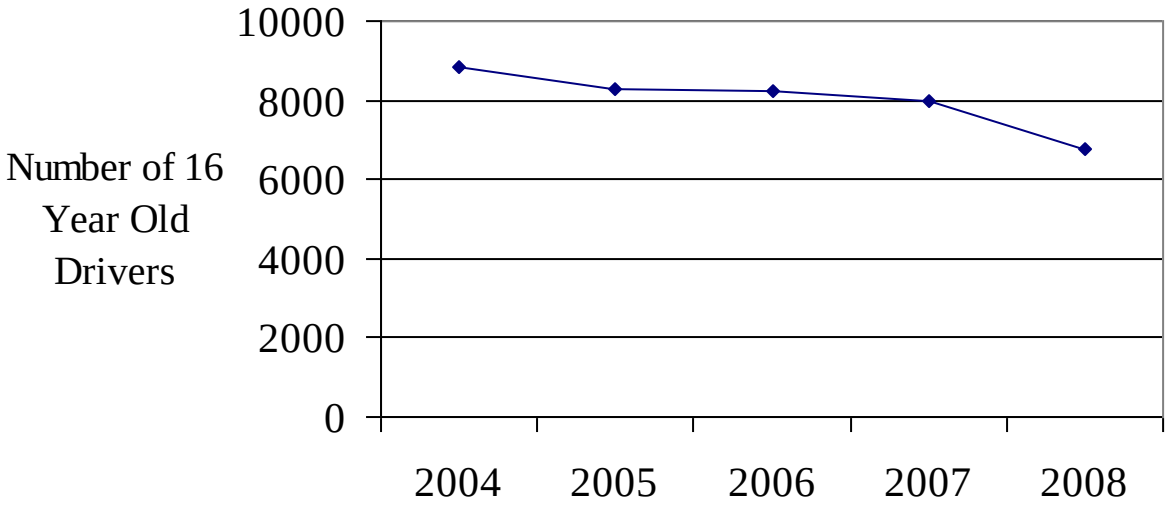

Figure 7. 2004 - 2008 State of North Carolina crashes involving 16 year old drivers[5].

In Michigan, no studies have been conducted on the passenger restrictions that came into effect in March 2011.

Cost

The costs to implement or revise passenger restrictions for intermediate licensed drivers are low. The greatest cost comes from notifying the public about the new restriction laws.

Implementation Issues

The only implementation issue for enacting passenger restrictions for intermediate licensed drivers is the amount of time required to notify the public and implement the changes (NHTSA, 2011). It typically takes around 6 months to implement the changes and notify the public.

[5] (2004 North Carolina Traffic Crash Facts, 2005; 2005 North Carolina Traffic Crash Facts, 2006; 2006 North Carolina Traffic Crash Facts, 2007; 2007 North Carolina Traffic Crash Facts, 2008; 2008 North Carolina Traffic Crash Facts, 2009)

SEAT BELT LAWS AND YOUTHS

Effectiveness: Medium **Cost:** Low **Implementation Issues:** Low

Overview

As of June 2011, every State except New Hampshire has implemented a primary or secondary law for adult seat belt use (GHSA, 2011a). All States have implemented laws requiring seat belt use for children. Fines for not using a seat belt range by State from $10 to $500, with some States like Alabama and California also assigning driver's license points for noncompliance with child passengers.

Michigan currently has a primary seat belt law, which allows a law enforcement officer to ticket a driver not wearing a seat belt without any other traffic offense taking place. The driver and all front seat passengers are required to wear a seat belt. Child restraint is mandatory for children younger than 8 years old (or <57" in height), and children 8 to 15 years old are required to wear a seat belt. Anyone 16 years or older is not required to wear a seat belt in the back seat of a vehicle.

Effectiveness

Boyle and Lampkin (2008) found that, nationally, teenage and young adult drivers, ages 16-24 years, are less likely to use seat belts (81%), compared to adult drivers, ages 25-69 (88%). Research has shown that properly used seat belts reduce the risk of serious to incapacitating injury to front seat passengers by 50% and the risk of fatal injury by 45% (NHTSA, 2000). Seat belts reduce the risk of fatal injury for light truck passengers by 60% and serious to incapacitating injury by 65%.

The National Highway Traffic Safety Administration has funded "Click it or Ticket" advertisement campaigns along with enforcement zones to increase awareness and seat belt use in many States. "Click it or Ticket" and the enforcement zones have significantly increased seat belt use for drivers and passengers located in States participating in the program (NHTSA, 2011).

Michigan has participated in the "Click it or Ticket" campaign and set up 800 designated seat belt enforcement zones in 55 of Michigan's 83 counties for two weeks around Memorial Day since 2001 (Datta & Savolainen, 2009). Seat belt use in Michigan has increased significantly from 2000 (83.5% of all drivers and passengers) to 2009 (97.9% of all drivers and passengers). In 2009, 97.3% of drivers and passengers, ages 16 to 29 years old, were observed wearing their seat belts after the "Click it or Ticket" campaign.

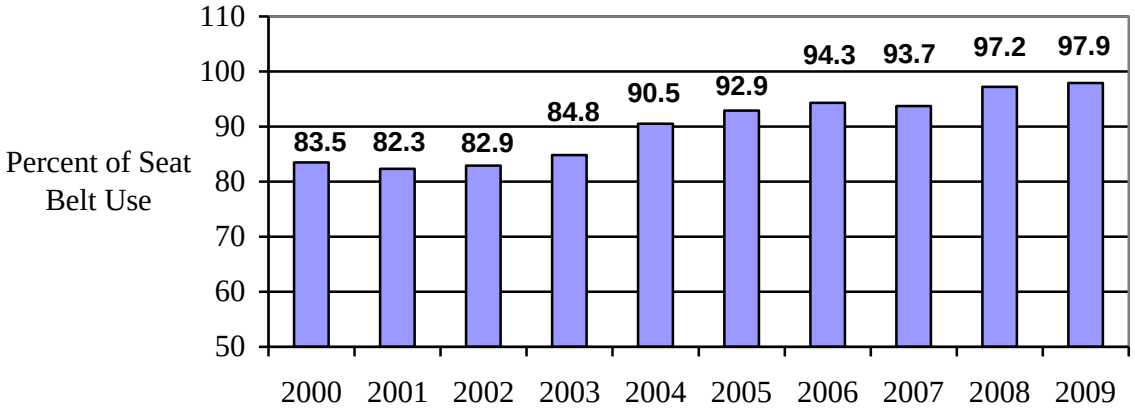

Figure 8. 2000 - 2009 State of Michigan, Percent of Seat Belt Use by Drivers and Front-seat Passengers (Source: Datta & Savolainen, 2009).

Unfortunately, no efforts or data regarding the effectiveness of any efforts that address seat belt use and young drivers specifically were found.

Cost

The costs associated with seat belt laws are for enforcement and publicity. Seat belt use can be observed easily and can be enforced during regular patrols. Additionally, the Michigan Office of Highway Safety Planning (OHSP) started running "Click it or Ticket" campaigns and enforcement zones, with cooperation from local law enforcement, in November, 2000. The advertising and enforcement costs traditionally have been paid for by funds from NHTSA.

Implementation Issues

Seat belt enforcement ad campaigns and coordination of enforcement zones with local officials can be time consuming. It can take four to six months to plan a successful campaign. However, when well executed, the combination of campaigns and enforcement zones can significantly increase seat belt use. Since Michigan began participating in "Click it or Ticket" seat belt use has increased by over 14%. Drivers and passengers benefit from advertising campaigns which enforce existing seat belt laws. Without such "reminders," some percentage of vehicle occupants are likely to "drift" away from seat belt usage on a regular basis, putting themselves at increased risk during crashes.

CELL PHONE USE RESTRICTIONS

Effectiveness: Medium **Cost:** Low **Implementation Issues:** Low

Overview

No state has placed a ban for all drivers on all cell phone use including hand held and hands free devices (GHSA, 2011b). Thirty states ban all cell phone use by novice drivers, and nine states prohibit all drivers from using hand held cell phones while operating a motor vehicle. Text messaging is currently prohibited in 34 states and an additional seven states prohibit novice drivers from text messaging while driving.

Michigan has banned all drivers from text messaging while driving since July, 2010 (GHSA, 2011). There are no laws that currently ban all drivers from all hand held cell phone use. However, novice drivers whose cell phone usage has contributed to a ticket or traffic crash are prohibited from all cell phone use while driving.

Effectiveness

It is still unclear if hand held cell phone bans are effective in reducing crashes (NHTSA, 2011). Nikolaev, Robbins, and Jacobson (2010) examined driving fatalities and injuries in New York State before and after a law prohibiting hand held cell phone use took effect. A significant decrease in injury crashes was observed for 46 counties and fatal crashes decreased in 10 counties out of the 62 counties examined. However, the study did not include a control group to account for any other confounding factors that may have decreased the number of crashes. The Highway Loss Data Institute investigated State-level automobile insurance collision claims in California, Connecticut, New York, and the District of Columbia. No change in collision claim frequency was observed for these jurisdictions when compared to neighboring States after the hand held cell phone bans were implemented (HLDI, 2009).

No studies have been conducted on the effectiveness of laws banning text messaging while driving or hand held cell phone bans for only novice drivers (NHTSA, 2011).

Cost

The only costs associated with cell phone laws are for enforcement and publicity. In order to support law enforcement effort, paid advertising may be necessary. Paid advertising is expensive; however, grants or partnerships with other organizations can offset the costs.

Implementation Issues

Hand held cell phone use and text messaging laws can be implemented quickly by publicizing the bans. Ad campaigns in coordination with law enforcement can be highly effective in curbing

text messaging and hand held cell phone use among drivers (Cosgrove, Chaudhary, & Roberts, 2010).

YOUTH PROGRAMS

Effectiveness: Medium **Cost:** Medium **Implementation Issues:** Low

Overview

Youth programs aimed at the prevention of drinking and driving have been conducted in every state (NHTSA, 2011). The primary focus of these programs is to motivate teenagers not to drink, not to drink and drive, and not to ride in a vehicle with a driver who has been drinking. Many programs provide positive role models and encourage youth activities that do not lead to or involve alcohol use.

Students Against Destructive Decisions (SADD) is a youth program that has nearly 350,000 active student members (SADD, 2010). SADD programs focus on informing and preventing youth from making poor decisions concerning a variety of issues including drug use, and drinking and driving.

Social norms programs provide students with accurate information about drug use and drinking to reduce the pressure that non substance users experience, and to show heavy substance users that their drug or alcohol use is atypical (NHTSA, 2011).

Effectiveness

Hedlund, Ulmer, and Preusser (2001) conducted a study in six schools and found that SADD successfully affected drinking and driving attitudes in addition to self reported drinking and driving. A second study of two schools where the SADD program was not well implemented found no effect on drinking and driving.

Goodwin (2004) found a marginally significant decrease in drivers who positively registered on a BAC test after the implementation of a social norms program at a public university. Also, the number of self reported drinks consumed and measured BACs decreased for the drivers who had been drinking.

Cost

The cost for youth programs varies substantially depending on the type and size of the activities planned (NHTSA, 2011). Some Federal funding is available for drinking and driving programs that focus on youth education, enforcement, and program activities.

Implementation Issues

Implementation of youth programs can be easily started with assistance from organizations like SADD. Many schools in Michigan already have an active SADD chapter.

SCHOOL EDUCATION PROGRAMS

Effectiveness: Low **Cost:** Low **Implementation Issues:** Medium

Overview

Many schools in the United States cover impaired driving, traffic safety, and alcohol use as topics in driver education and health classes (NHTSA, 2011). Most students are required to take a health education course; however, the drinking and driving issue may or may not be part of the curriculum. Driver education is offered at some public schools and at commercial driving schools, but the coverage of drinking and driving can significantly vary depending on the program.

Effectiveness

Stewart (1999) found preventative school education programs have only a weak and inconsistent effect on teenager alcohol use. Insufficient evidence is available to determine the effectiveness of school education programs for reducing drinking and driving among teenagers (Elder, Nichols, Shults, Sleet, Barrios, & Compton, 2005).

Cost

There are relatively low costs associated with school education programs. Many schools include education on alcohol and impaired driving in health and driver education courses.

Implementation Issues

At least a year is required to plan, acquire material, train teachers, and schedule a school education program.

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DISTRACTED DRIVING

Overview

Distracted driving is common, but it is difficult to define, measure, and sometimes observe (NHTSA, 2011). Few behavioral countermeasures have been shown to reduce distracted driving based on the fact that distracted driving results mainly from lifestyle choices and patterns.

Distracted driving occurs when a driver focuses their attention on some other activity and away from driving. A distracted driver is distinguished from other inattentive drivers by the presence of a triggering event. A distraction can be induced by a physical task such as operating the radio or reaching to open the glove compartment, mental activities such as cell phone conversations, or by something a driver hears or sees (NHCRP, 2005). The attention a driver devotes to the driving task ranges from high to low. Most distracting thoughts and actions are brief and may occur almost continuously while driving.

In 2009, 5,474 people were killed in police reported crashes involving driver distraction and approximately 448,000 people were injured (NHTSA, 2010). Driver distraction was involved in an estimated 10% of all fatalities in 2005 and increased to 16% in 2009. Distraction may play an even higher role in crashes because many pre-crash distractions often leave no evidence, and after a crash drivers are reluctant to admit to being distracted. Figure 9 depicts the number of crash fatalities due to driver distraction from 2005 to 2009.

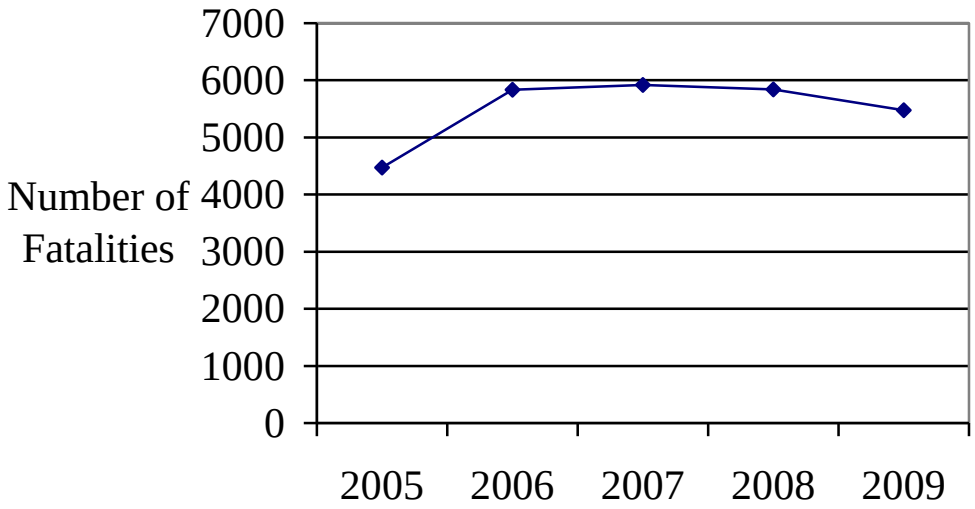

Figure 9. 2005 - 2009 United States crash fatalities due to driver distraction. (NHTSA, 2010)

Between 2005 and 2007, NHTSA's National Center for Statistics and Analysis conducted the National Motor Vehicle Crash Causation Survey (NMVCCS) in an attempt to understand the

role of inattention in the occurrence of vehicle crashes (Singh, 2010). Immediately following a crash, information was collected on the driver, vehicle, environment, and roadway related factors. Drivers age 16 to 25 years were distracted most (about 22 percent) by one or more internal sources compared to more experienced drivers. The survey found the most significant internal distractions for drivers included conversing with a passenger, operating the radio, focusing on objects within the vehicle, observing the actions or movements of passengers, and conducting a phone conversation.

Klauer, Dingus, Neale, Sudweeks, and Ramsey (2006) conducted a study on distracted driving that monitored 100 drivers for a year using specialized instrumentation. The study found that secondary task distractions such as eating or dialing a cell phone contributed to 22 percent of the crashes and near crashes which occurred while the study was in progress.

Many states and organizations have implemented countermeasures in an attempt to reduce the number of distracted driving crashes. Graduated driver licensing (GDL) restrictions (including nighttime, number of passengers, and cell phone use) have been placed on novice drivers in most states (IIHS, 2011; NHTSA, 2011). Limitations on hand held cell phone use and text messaging have been implemented by numerous states (GHSA, 2011). Several national organizations and states have conducted distracted driving campaigns to inform the public about the dangers of driving while distracted (AAAFTS, 2004; NCHRP, 2005). Many businesses have enacted distraction free driving policies for their employees and the National Safety Council (NSC) has developed a Cell Phone Policy Kit to help employers implement a distraction free driving program (NSC, 2010).

In Michigan, driving while seriously distracted is covered by the reckless and careless driving laws. Michigan implemented a GDL program for novice drivers under 18 years old and a cell phone texting ban for all drivers (GHSA, 2011; IIHS, 2011; NHTSA, 2011). However, Michigan does not currently have a law specifically covering general distracted driving, nor a way to document or track distracted driving crashes.

Table of Summary Ratings. Table 5 contains an estimate of each countermeasure's effectiveness, cost, and issues for implementation. The ratings follow the system previously described.

Table 5. Estimates of each distracted driving countermeasure for effectiveness, cost, and implementation issues.

Countermeasure	Effectiveness	Cost	Implementation Issues
Cell Phone Use	Medium	Low	Low
General Driver Distraction Laws	Low	Low	Low
Communications and Outreach	Low	Medium	Low
Employer Programs	Low	Low	Low

CELL PHONE USE RESTRICTIONS

Effectiveness: Medium **Cost:** Low **Implementation Issues:** Low

Overview

No state has placed a ban for all drivers on all cell phone use including hand held and hands free devices (GHSA, 2011). Thirty states ban all cell phone use by novice drivers, and nine states prohibit all drivers from using hand held cell phones while operating a motor vehicle. Text messaging is currently prohibited in 34 states and an additional seven states prohibit novice drivers from text messaging while driving.

In Michigan, all drivers have been prohibited from text messaging while driving since July, 2010 (GHSA, 2011). For a first offense, motorists will be fined $100. Subsequent offenses will be $200. There are no laws that currently ban all drivers from all hand held cell phone use. However, novice drivers whose cell phone usage has contributed to a ticket or traffic crash are prohibited from all cell phone use while driving.

Figure 10 depicts the number of reported crashes involving a driver using a cell phone in Michigan; however, no distinction is made between whether drivers were talking or texting at the time of the crash.

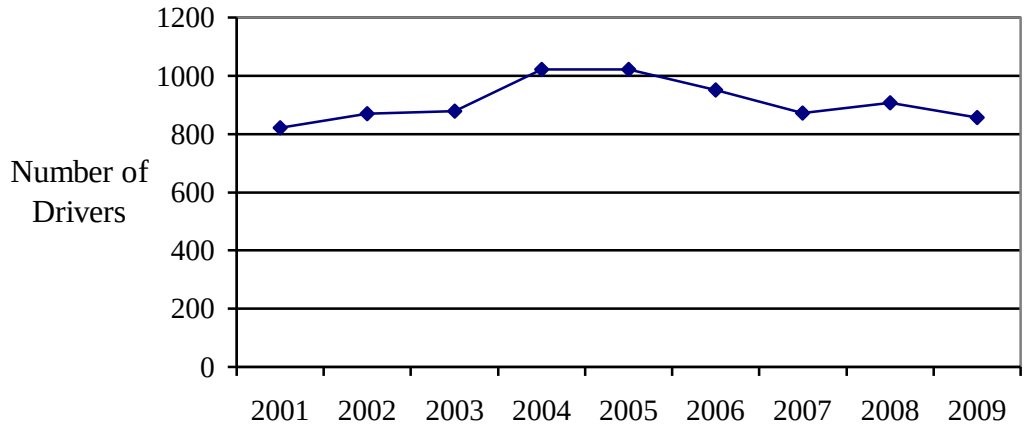

Figure 10. 2001 - 2009 State of Michigan reported crashes involving a driver using a cell phone[6].

[6] 2001 Michigan Traffic Crash Facts, 2002; 2002 Michigan Traffic Crash Facts, 2003; 2003 Michigan Traffic Crash Facts, 2004; 2004 Michigan Traffic Crash Facts, 2005; 2005 Michigan Traffic Crash Facts, 2006; 2006 Michigan Traffic Crash Facts, 2007; 2007 Michigan Traffic Crash Facts, 2008; 2008 Michigan Traffic Crash Facts, 2009; 2009 Michigan Traffic Crash Facts, 2010).

Effectiveness

It is still unclear if hand held cell phone bans are effective in reducing crashes (NHTSA, 2011). Nikolaev, Robbins, and Jacobson (2010) examined driving fatalities and injuries in New York State before and after a law prohibiting hand held cell phone use took effect. A significant decrease in injury crashes was observed for 46 counties and fatal crashes decreased in 10 counties out of the 62 counties examined. However, the study did not include a control group to account for any other confounding factors that may have decreased the number of crashes. The Highway Loss Data Institute (HLDI) investigated State-level automobile insurance collision claims in California, Connecticut, New York, and the District of Columbia. No change in collision claim frequency was observed for these jurisdictions when compared to neighboring States after the hand held cell phone bans were implemented (HLDI, 2009).

No studies have been conducted on the effectiveness of laws banning text messaging while driving or hand held cell phone bans for only novice drivers (NHTSA, 2011).

Cost

The only costs associated with cell phone laws are for enforcement and publicity. In order to support law enforcement effort, paid advertising may be necessary. Paid advertising is expensive; however, grants or partnerships with other organizations can offset the costs.

Implementation Issues

Hand held cell phone use and text messaging laws can be implemented quickly by publicizing the bans. Ad campaigns in coordination with law enforcement can be highly effective in curbing text messaging and hand held cell phone use among drivers (Cosgrove, Chaudhary, & Roberts, 2010).

Text messaging is currently banned for all drivers in Michigan. The Michigan Office of Highway Safety Planning (OHSP) launched a "Thumbs on the Wheel" campaign that included posters, billboards, and public service announcements in June 2010 (GHSA, 2010). OHSP used federal traffic safety funds to offset costs for the campaign.

GENERAL DRIVER DISTRACTION LAWS

Effectiveness: Low **Cost:** Low **Implementation Issues:** Low

Overview

Every state prohibits driving while seriously distracted through general reckless driving laws (NCHRP, 2005). Drivers can be cited and prosecuted if they cause a crash due to distracted driving with the existing laws. However, it is unknown to what extent states currently pursue cases of distracted driving.

Maine enacted a general distracted driving law in 2009 (NHTSA, 2011). The law stipulates a driver who commits an infraction or who is involved in a crash may be cited for distracted driving if a police officer believes that driver distraction was the underlying cause. Distraction is defined as engaging in an activity not vital to the operation of the vehicle and that could or does impair the ability to drive safely.

Currently, Michigan does not have a general distracted driving law.

Effectiveness

No studies have been conducted to determine the effectiveness of distracted driving laws. However, distracted driving laws are unlikely to have a significant effect on driver behavior unless they are rigorously enforced and publicized (NHTSA, 2011).

In Michigan, driver distraction can only be reported by the investigating officer of a crash if the driver admits to the condition (2009 Michigan Traffic Crash Facts, 2010). This may lead to possible under reporting of driver distraction as a condition contributing to a crash.

Cost

The costs for driver distraction laws are limited to enforcement and publicity campaigns. Distracted driving can be enforced during regular patrols. The cost for publicity campaigns can be high, but the cost can be offset by partnerships with other organizations or grants.

Implementation Issues

The time to implement a distracted driving law can vary, depending on the behavior the law is targeting. In general, laws that have public support are more likely to be implemented quickly compared to laws that lack public support. Another issue with implementing a distracted driving law is agreeing on the definition of driving distraction. Finally, the time to implement a distracted driving law is also limited by how quickly it is publicized and training law enforcement officers.

COMMUNICATIONS AND OUTREACH ON DISTRACTED DRIVING

Effectiveness: Low **Cost:** Medium **Implementation Issues:** Low

Overview

There are several obstacles that face distracted driving communications and outreach (NHTSA, 2011). At some level, all drivers are aware that they should be alert. However, there are many forms of distractions both inside and outside of a vehicle. It can be difficult to control many distractions within a vehicle such as children and conversations. Some distractions within a vehicle such as listening to the radio and eating are intentional and may be useful in keeping drivers alert on long trips. Drivers do not have control over distractions outside of the vehicle.

Several national organizations, such as the AAA Foundation for Traffic Safety (AAAFTS), and States, including New York and California, have provided material for or conducted distracted driving campaigns directed to the general public (AAAFTS, 2004; NCHRP, 2005). The campaigns vary between a general pay attention message and targeting specific behaviors including cell phone use. To discourage distracted driving the U.S. Department of Transportation has launched a national campaign called "Put It Down", which suggests an expectation that drivers should not be holding anything in their hands other than the steering wheel.

The Michigan Office of Highway Safety Planning (OHSP) launched a "Thumbs on the Wheel" campaign that included posters, billboards, and public service announcements in June 2010 directed at texting while driving (GHSA, 2010). A general distracted driving campaign has not been implemented in Michigan.

Effectiveness

No studies have been conducted on the effectiveness of distracted driving campaigns on driver behavior, knowledge, or attitudes (NCHRP, 2005).

Cost

It is expensive to develop, test, and implement a high quality distracted driving campaign. The cost can be offset by grants or partnerships with other organizations.

Implementation Issues

The main obstacle to developing a distracted driving campaign is the amount of time it can take.

EMPLOYER PROGRAMS

Effectiveness: Low **Cost:** Low **Implementation Issues:** Low

Overview

The National Safety Council (NSC) has developed a Cell Phone Policy Kit to help employers implement a distraction free driving program (NSC, 2010). The kit primarily focuses on implementing a corporate cell phone ban and promoting distraction free driving by creating a 12 month safety calendar (including April which is Distracted Driving Awareness Month), and using posters and fact sheets from the NSC.

In 2010, NSC conducted a distracted driving survey which found 37 percent of employers ban all driver cell phone use, and 28 percent of employers ban hand held cell phone use (NSC, 2011). The remaining 35 percent of employers do not have a formal distracted driving policy. Out of the organizations that responded to the survey, 99 percent of the businesses banning employees from all cell phone use while driving reported no decrease in productivity.

In 2009, President Obama issued an executive order banning Federal employees and Federal contractors from text messaging while driving (Obama, 2009). The prohibition on texting while driving applies to Federal employees and Federal contractors who are conducting official business or using government supplied equipment. However, agencies engaged in national security responsibilities, law enforcement, or during emergency conditions are exempt from the executive order.

Michigan currently bans all drivers from texting while driving, which includes state government employees (GHSA, 2011).

Effectiveness

No studies have been conducted on the effectiveness of distracted driving employer programs in changing employee driver behavior, knowledge, or attitudes (NHTSA, 2011; NSC, 2011).

Cost

The costs associated with implementing a distracted driving employer program are covered by the individual organization.

Implementation Issues

The time required to implement a distracted driver employer program varies with each organization. The NSC offers a Cell Phone Policy Kit to give tips to employers on how to implement a distracted driving policy for employees (NSC, 2010).

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DROWSY DRIVING

Overview

There are many reasons why someone may drive drowsy (e.g., sleep deprivation, shift work effects, medications) but simply put, drowsy driving is the combination of driving and being fatigued/sleepy. The effects of drowsy driving can have significant negative effects on one's ability to drive an automobile, with vehicle crashes being an unfortunate result.

The AAA Foundation for Traffic Safety (AAAFTS) recently conducted a telephone survey in which they asked respondents aged 16 years or older if they had "ever fallen asleep or nodded off, even just for a second or two," while they were driving (AAAFTS, 2010). Two of every five drivers (41.0%) reported having fallen asleep or nodded off while driving. Twenty-two percent of those respondents reported that they had done so within the past year. Thus, nearly one in ten respondents reported that they had fallen asleep or nodded off in the past year.

These results are consistent with other surveys that demonstrate that drowsy driving is a significant problem. In a series of surveys conducted by the National Sleep Foundation (NSF) the percent of respondents who reported having previously driven while considering themselves drowsy has ranged from 51% to 60%, with 17% of all respondents reporting that they had fallen asleep at the wheel in the previous year (NSF, 2002, 2005, 2011). In a 2008 poll, 38% of the respondents reported that they had fallen asleep while driving at some point in their life.

In a series of surveys conducted by the NSF 1%-2% of the respondents reported that they had a crash that they felt was caused by drowsy driving (NSF 2002, 2008). NHTSA estimates that nationally in 2009, drowsy driving resulted in approximately 72,000 crashes involving property damage, an injury, or a fatality, representing 1.3% of all vehicle crashes. Drowsy driving related crashes led to 832 fatalities (NHTSA, 2011a).

Young people tend to be one of the segments of the driving population that are most at risk for drowsy driving. In a series of surveys conducted by the NSF, 66% to 71% of the respondents aged 18-29 years old were likely to drive or to have driven drowsy, compared to 57% of respondents aged 30-45 years old, 44% of respondents aged 46-64 years old, and less than 20% of respondents aged 65 years or older (NSF, 2002, 2011). A 2006 NSF study found that 51% of adolescents (children 17 and under) who are able to drive reported that they had driven drowsy in the past year, with 15% reporting that they drive drowsy at least once a week. Five percent of the adolescent respondents in the 2006 study reported that they had actually fallen asleep while driving in the past year.

Interestingly, 59% of adults with children are likely to drive while drowsy. Regarding any gender differences in drowsy driving, 56% of men reported having driven drowsy in the past

compared to 45% of women. In addition, men were found to be nearly twice as likely as women (22% to 12%) to actually fall asleep at the wheel (NSF, 2002).

Most drowsy-related crashes occur overnight, (between midnight and 6 a.m.) and middle afternoon (between noon and 5 p.m.). Thus, drowsy driving is a problem during the day as well as at night. About one-third of those drivers who admit falling asleep at the wheel say that it occurred in the afternoon (between noon and 5 p.m.; AAAFTS, 2010).

Other groups of individuals who are at risk for drowsy driving are commercial drivers, irregular shift workers, persons with sleep disorders (e.g., sleep apnea), and individuals who are taking medications that can make them drowsy. It has been reported that among commercial drivers 1% of all large-truck crashes, 3–6% of fatal heavy-truck crashes, and 15–33% of fatal-to-the-truck-occupant-only crashes have been attributed to driver fatigue (Knipling and Shelton, 1999). Other research has demonstrated that individuals with sleep apnea are six times more likely to be involved in a crash than those without sleep apnea (Teran-Santos, Jiminez-Gomez, & Cordero-Guevara, 1999). Finally, while the effects of different mediations on drowsiness vary, the research conclusively shows that taking some medications prior to driving can be dangerous because of the likelihood of experiencing driver fatigue (NCHRP, 2005).

Strategies to Reduce Drowsy Driving. The root cause of drowsy driving is fatigue. Thus, the simplest approach is to encourage people to make sure they get an adequate amount of sleep before driving. Some of the countermeasures herein are aimed at doing that. However, in the case that a person is fatigued, countermeasures have been developed in attempts to deter a person from actually driving a vehicle. Finally, if someone chooses to drive even though he/she is drowsy, measures can be taken to help drivers maintain awareness on the road until they reach a point where they can pull over.

Table 6 contains a list of the countermeasures reviewed herein and an estimate of each countermeasure's effectiveness, cost, and issues for implementation. The ratings follow the system previously described.

Table 6. Estimates of each drowsy driving countermeasure for effectiveness, cost, and implementation issues.

Countermeasure	Effectiveness	Cost	Implementation Issues
Communication & Outreach Programs	Low	Medium	Low
Employer Programs	Low	Low	Low
Centerline and Shoulder Rumble Strips	High	Medium	Low
Drowsy Driver Laws	Medium	Low	Low
Medical Conditions & Medications	Low	Medium	Medium

Finally, because it doesn't fit any of the categories listed, we thought we should note the findings of a recent study published by Danner & Phillips (2008). They surveyed adolescents of legal driving age in Kentucky both before and after the implementation of a one hour delay in the school start time. They found that delaying school by one hour reduced crash rates for teen drivers by 16.5%. In contrast, teen crash rates for the rest of the state increased by 7.8%. This was attributed to an increase in nightly sleep and a decrease in "catch up" sleep on the weekends.

COMMUNICATION AND OUTREACH PROGRAMS

Effectiveness: Low **Cost:** Medium to High **Implementation Issues:** Low

Overview

A number of organizations (e.g., NSF, the AAAFTS, and the Advocates for Highway and Auto Safety) have been conducting communications and outreach programs for the benefit of the general public for years. The ultimate objective of a campaign is to insure that people are fully rested when they drive a vehicle. Thus, the programs typically contain messages that encourage drivers to get more sleep. They also aim to educate drivers about the dangers of drowsy driving and how to determine if one is too fatigued to drive. Finally, in the case that someone is already driving and then starts to experience fatigue, they provide measures that the driver can take to reduce fatigue and improve safety.

The NSF annually promotes a program simply titled Drowsy Driving Prevention Week™ (DDPW). In 2011, DDPW will be held November 6-12. DDPW is a public awareness campaign designed to educate drivers about the dangers of drowsy driving. As part of the program, the NSF provides a toolkit with a varying assortment of sleep and drowsy driving prevention materials for the States or other entities to utilize as they execute their own campaign. The toolkit contains sample press materials, sample public service announcements (PSAs) in print, audio, and video format, fact sheets that can be used to create other materials, posters and presentations, and other miscellaneous materials.

In addition, States sometimes utilize similar materials provided by the NSF during a campaign called National Sleep Awareness week. For example, in 2009 the State of New York launched a radio campaign during National Sleep Awareness week that specifically targeted young drivers and shift workers. PSAs were developed that discussed the dangers of drowsy driving and offered measures that could be taken to prevent their occurrence.

Throughout the years Michigan has utilized the materials from both campaigns to varying degrees. For example, in 2003 Michigan's Office of Highway Safety Planning became a cooperative co-sponsor with the NSF to help promote that year's National Sleep Awareness week.

Michigan's activities in drowsy driving prevention also include a 2007 symposium in Grand Rapids, Michigan called "Wake-Up Michigan". The symposium included several presentations on topics such as legislative approaches to drowsy driving, roadway engineering countermeasures, who is at risk, and driver monitoring systems (see http://www.michigan.gov/documents/michnets/Wake_Up_Michigan_Symposium_registration_form_201909_7.pdf).

Effectiveness

Unfortunately, no evaluations on the effectiveness of drowsy driving campaigns specifically have been completed. However, research on campaigns in other driver behavior problem areas indicate that such programs are minimally effective unless the campaign is both multi-faceted (i.e., multiple mediums are used to communicate to the general public) and extensive (i.e., a significant amount of time and money has to be invested to insure the message is communicated well to the general public; Williams, 2007).

Cost

The costs for a program can vary greatly. Development of many of the materials that would be used has already been completed; unless a decision is made to customize or develop additional materials, the cost is negligible. The costs can increase significantly the larger the program is. The addition of advertising on radio and television can increase costs significantly.

***Implementation* Issues**

Most foundations like NSF are willing to develop these types of programs and execute the campaigns at a national level. Often, they are simply toolkits that States and other entities need to apply. However, if customization of materials or further development is desired, then the time to implement can increase significantly.

EMPLOYER PROGRAMS

Effectiveness: Low **Cost:** Low **Implementation Issues:** Low

Overview

Employees who tend to work irregular work schedules (i.e., extended lengths, non-daytime hours), which includes commercial drivers, tend to be high risk for drowsy driving. As a result, many employers with employees at high risk for drowsy driving are utilizing one or more of an assortment of resources available for addressing drowsy driving.

For example, many companies have utilized the materials developed as part of NHTSA's "Wake Up and Get Some Sleep" project. The project was a collaboration between NHTSA and the National Center on Sleep Disorders Research (NCSDR) with the stated goal of "increase(ing) shift workers' awareness of the dangers of drowsy driving, help(ing) them to improve the quality of their sleep and reduce sleepiness, and ultimately, reduc(ing) the incidence of drowsy driving." The program includes a number of materials that can be distributed throughout a company and customized to fit the specific needs of the employer. The materials include a video, posters, fact sheets/brochures, cards with tips to improve sleep, a PowerPoint training guide for employers, and a brochure for the families of the shift workers themselves (see icsw.nhtsa.gov/people/injury/drowsy_driving1/human/drows_driving/index.html).

Another program developed by the American Transportation Research Institute (ATRI) commercial vehicle employers can use is titled "Understanding Fatigue and Alert Driving." It is similar to the NHTSA/NCSDR program except it tends to spend more time training managers as opposed to providing materials to the employees themselves.

In addition, employers can become members of an organization titled the "Network of Employers for Traffic Safety" (NETS). NETS members are provided access to number of different materials, some like those described above, that they can use to develop internal drowsy driving campaigns (as well as campaigns for other driver behavior problem areas).

Finally, every year Utah hosts a "Zero Fatalities Safety Summit" in which they discuss ways to prevent drowsy driving, among other topics. One of the purposes of the "Zero Fatality" program in Utah is to give employers help with start programs and to teach employees about drowsiness and prevention techniques (http://ut.zerofatalities.com/summit/).

Employers in the State of Michigan are able to utilize any of the programs made available by other organizations.

Effectiveness

The effect of employer programs on the incidence of drowsy driving has not been studied in depth and is therefore unknown. However, the NHTSA/NCSDR program was evaluated in

regards to its appeal to both employers and employees and received favorable reviews (NCHRP, 2005).

Cost. The implementation of a program is only costly to the extent that an employer wishes to customize or further develop the program. Further, while waiting to implement the program productivity will continue to suffer, therefore the time before implementation is complete can be considered costs to the employer. However, these are not costs incurred by the State itself.

***Implementation* Issues**

It is up to employers to receive the information for these programs. It is difficult for the State to supervise these programs properly unless it is offered through the State.

CENTERLINE AND SHOULDER RUMBLE STRIPS

Effectiveness: High **Cost:** Low **Implementation Issues:** Medium

Overview

Rumble strips are a relatively simple engineering countermeasure. They are small lateral grooves or raised ridges placed on the side of the road or on the travel lanes themselves. When drivers travel over them, a sound is created and tactile vibrations are felt by the driver, both of which are particularly effective at alerting fatigued drivers that they are about to leave the lane or miss a critical decision point in the driving task (e.g., slow down for a toll booth). Rumble strips are particularly effective at preventing single-vehicle-run-off-road (SVROR) crashes (NCHRP, 2009).

In 2008 Michigan began a three year program to install 5,700 miles of centerline rumble strips on rural, non-freeway roads and approximately 1,700 miles of shoulder rumble strips.

Effectiveness

Recent research conducted by the NCHRP (2009) has shown that shoulder rumble strips are particularly effective at reducing SVROR crashes (which are often associated with drowsy driving, along with distracted or inattentive driving). Implementation of shoulder rumble strips was found to reduce fatality- and injury-related SVROR crashes by 16 % on rural freeway and 29% on rural two lane roads.

Further, the rumble strips were found to be more effective when they were placed closer to the edgeline for rural freeways but not when they were placed closer to the edgeline for rural two lane roads. On rural multi-lane divided highways, shoulder rumble strips were found to reduce SVROR crashes which resulted in a fatality or injury by 51% (Carrasco et al., 2004). Shoulder rumble strips were not found to reduce crash rates significantly after being installed on urban freeways.

Research has also shown centerline rumble strips are particularly effective at reducing head-on and opposite direction sideswipe crashes (which are often associated with drowsy driving, along with distracted or inattentive driving; NCHRP, 2009). Implementation of centerline rumble strips was found to reduce fatality- and injury-related head-on and opposite direction sideswipe crashes by 64% on urban two lane roads and 44% on rural two lane roads compared to rates prior to their implementation.

Morena (2003) conducted an analysis of shoulder rumble strips and found that they reduced SVROR crashes by 39% compared to rates prior to their implementation. It should be noted that the rumble strips analyzed were typically farther offset from the roadway than other states. In light of the finding mentioned above that rumble strips placed closer to the edgeline were more effective on rural freeways, Michigan now places rumble strips closer to the edgeline.

However, while these numbers demonstrate that the implementation of rumble strips leads to significant reductions in crash types often associated with rumble strips (e.g., drowsy, distracted), their effect on the fatigue levels of the drivers is momentary. In a study conducted by Anund et al. (2008), it was found that while alertness initially increased after driving over a rumble strip, fatigue returned in approximately five minutes. While a rumble strip may wake a driver temporarily, it will not keep one from driving drowsy if he/she continues to drive.

Cost

The previously mentioned initiative by the State of Michigan to install centerline and shoulder rumble strips was projected to cost the State $8 million.

Implementation Issues

The engineering and construction of the rumble strips is simple. However, rumble strips are sometimes met with objections from the general public because of the noise they create, issues they create for bicyclists, etc.

DROWSY DRIVER LAWS

Effectiveness: Medium **Cost**: Low **Implementation Issues**: Low

Overview

Existing reckless driving laws in most states can be used to target drowsy driving, but are rarely used. To date, New Jersey is the only state that has implemented a law specifically targeting drowsy driving. In 2003, "Maggie's Law" was passed, which allows for drivers to be prosecuted with vehicular homicide if they have not slept for 24 hours prior to causing a crash that results in a fatality.

No law exists at the national level. "Maggie's Law: National Drowsy Driving Act of 2003" was introduced with the intended purpose of providing incentives to States for the development of traffic safety programs to reduce crashes related to driver fatigue and sleep deprivation. However, the bill never became law.

Currently in Michigan there is no law specifically targeting drowsy driving like that of "Maggie's Law".

As previously mentioned, motor carriers are one of the driving populations at risk for drowsy driving. To combat drowsy driving among commercial drivers, the Federal Motor Carrier Safety Administration (FMCSA) has implemented regulations (49 CFR Part 395) that limits when and for how long commercial drivers may operate. Some of the regulations implemented for drivers carrying property include being able to drive a maximum of 11 hours after 10 consecutive hours off duty, not being able to drive after 60/70 hours on duty in 7/8 consecutive days, plus having to spend at least 8 hours in the sleeping cabin. Drivers carrying passengers are slightly more restrictive.

Effectiveness

There is no documented evidence on the effects of legislation or regulations on the incidence of drowsy driving. However, as documented elsewhere in this report, these laws are likely to be most effective when they are part of a multi-faceted program to address drowsy driving.

Cost

The cost concerns with drowsy driving laws are minimal. Enforcement of drowsy driving laws is likely to be included in the regular routine of law enforcement officers. The only costs incurred would be those needed to promote the law.

Implementation Issues

The biggest obstacle to implementation is simply passing the law. After the law is passed, all the other implementation issues are minimal.

MEDICAL CONDITIONS AND MEDICATIONS

Effectiveness: Low **Cost:** Medium **Implementation Issues:** Medium

Overview

The effects of sleep apnea and narcolepsy on drowsy driving has been documented extensively (NCHRP, 2005; NHTSA 1998). Sleep apnea is a condition in which an individual momentarily stops breathing during sleep (leading to awakening and restless sleep) multiple times throughout the night, which can cause excessive sleepiness during daytime hours. Research shows that individuals with sleep apnea are 6 times more likely to be involved in a crash than those without sleep apnea (Teran-Santos, Jiminez-Gomez, & Cordero-Guevara, 1999). Narcolepsey is a condition in which an individual unexpectedly falls asleep, without warning. Someone with narcolepsy can fall asleep while driving a vehicle.

While sleep apnea and narcolepsy are the most commonly discussed, there are a number of other medical conditions that can lead to excessive fatigue during the daytime hours and potentially lead to instances of drowsy driving (e.g., low back pain, migraine headache). In essence, any medical condition that makes it difficult to sleep could potentially lead to instances of drowsy driving. In addition, a number of medications are known to cause drowsiness (e.g., Benadryl, Xanax), which could also lead to incidences of drowsy driving.

The primary approach to addressing medical conditions and medications has been through campaigns and outreach programs. For example, in 2004 the NSF and FMCSA released a toolkit aimed at commercial vehicles drivers with sleep apnea called "Get on the Road to Better Health." Like the toolkit programs previously described, the toolkit contains a number of different print and multimedia educational materials. This toolkit was utilized collaboratively by The Ingham Center for Sleep & Alertness at the Ingham Regional Medical Center in Lansing, Michigan, and the Michigan State Police Motor Carrier Division in an effort to educate and screen commercial vehicle operators. In general, this program was deemed a very successful program and model for how an enforcement division can partner with the medical community to execute a program provided like the "Get on the Road to Better Health" program and provide free sleep screenings and education (NCHRP, 2005).

Finally, while only one state (New Jersey) has a drowsy driving law in place, DUI laws are increasingly also coming into play in drowsy driver cases where the fatigue was caused by medication.

Effectiveness

The effectiveness of attempts to reduce the incidence of drowsy driving caused by medical conditions or medication has not been studied. However, as with most campaign and outreach programs, communication must be extensive for the program to be effective.

Cost

The costs for a program can vary greatly. Development of many of the materials that would be used has already been completed; unless a decision is made to customize or develop additional materials, the cost is negligible. The costs can increase significantly though the larger the program is. The addition of advertising on radio and television can increase costs significantly.

Implementation Issues

Starting up an outreach program can take time and money to implement (e.g., in terms of raising awareness among various groups, developing mailing lists). However, once the program is started the upkeep is relatively low.

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OLDER DRIVERS

Overview

At first glance, older drivers (drivers 65 or older) might not appear to be a population segment at significantly higher risk for vehicle crashes and fatalities than other population segments. In fact, on a per licensed driver basis, the general population of the U.S. is twice as likely to get into a crash than older drivers (NCHRP, 2005). However, analyses of actual vehicle miles traveled and the fatality rates indicates otherwise; older drivers are in fact involved in more fatal vehicle crashes than any segment of the population except for drivers aged 16-34 years. Compared with an overall fatality rate of 2 per 1,000 crashes, persons ages 65–74 years have a fatality rate of 3.2 per 1,000 crashes. Older drivers comprised 16% of all traffic fatalities in 2009 (NHTSA, 2011).

Older drivers are a significant concern not only because of the higher risks for crashes, but because the older population is growing at such a rapid pace. The older population is expected to grow rapidly between now and 2050. In 2009, 40 million people (13% of the total U.S. resident population) were age 65 years and older. The percentage of persons 65 years and older is projected to increase to 19% by 2030, and the total number of persons 65 years and older is projected to more than double by 2050 to 88.5 million. The main reason for such dramatic growth is the baby boomer generation (defined as persons born between 1946 and 1964, including 1964); beginning in 2011 the baby boomer generation will being to fall into the classification of an older person (a person 65 years or older; Vincent and Velkoff, 2010). An additional cause of the increase in the older population is the lengthening life expectancy of the U.S. population. Life expectancy is expected to increase by 5 years for males and 4 years for females by 2050 (Shrestha, 2006).

Nationally, there were 32 million licensed older drivers in 2008 (NHTSA, 2010). In the State of Michigan, the number of older drivers was just over 1 million (Michigan Senior Mobility Action Plan, 2009). Nationally, the number of licensed older drivers increased by approximately 20% in the past ten years, whereas the increase in the State of Michigan was 12%. Many older drivers move out of state to warmer climates which may account for much of this difference.

Older drivers tend not to engage in risky driving behavior, unlike drivers aged 18-34 years. For example, in 2009 only 5% of all crashes involved drivers 65 years and older who had a BAC greater than 0.08. In contrast, the percentage of crashes where the driver had a BAC greater than 0.08 among drivers aged 16-20, 21-34, and 35-54 years were 19%, 33%, and 24% respectively. In addition, drivers tend to decrease the amount of miles they drive as they age which limits their exposure and would seem to lead to reductions in crash rates.

For these reasons, one could presume that serious injury and fatalities should decrease as drivers age. However, older driver tend to be more at risk because of general declines in cognitive,

perceptual, and physical functioning. Over time, older drivers tend to develop significant deteriorations in one or combinations of a number of skills that are necessary for driving including vision, attention, the physical abilities needed to control the vehicle (e.g., arthritis), and cognitive decline (e.g., decreased reaction times, decreased memory abilities). These declines in functioning may be significant contributors to vehicle crashes (e.g., pull-outs into traffic, failing to see and stop at red lights).

In addition, fatality rates may be higher for older drivers simply because as people age they become more fragile (i.e., the likelihood of a serious injury or fatality increases compared to a younger, healthier person). In fact, Li, Braver, & Chen (2003) found that the increase in fatality rates as drivers age is caused primarily by the increase in the frailty of the drivers themselves and not an increase in crash rates. Finally, while older drivers tend to be less risky, often adjustments made to their driving patterns are dangerous as well.

Strategies to Reduce the Incidence of Crashes and Fatalities Involving Older Drivers. One approach to addressing the older driver problem is to improve the ability to identify those drivers at risk and intervene. As previously described, some older drivers develop significant deteriorations in one or a combination of a number of skills that are necessary for driving. Improved screening can be implemented through changes in licensing screening and testing procedures or through the education of law enforcement officers in the identification of markers for high risk among older drivers.

After identifying that an older driver is high risk, it may be necessary to intervene by removing their license. In other instances the older driver may be able to improve their fitness to drive, thereby reducing the risk to themselves and others on the road. In these cases, courses for older drivers have been developed for this purpose. In addition, medical advisory boards may be utilized to help aid in the identification of high risk older drivers and in the recommendation license removal or in the implementation of measures that address the cognitive, perceptual, and physical functioning decline previously mentioned.

Campaigns to increase awareness have been developed in attempts to reduce the incidence of fatalities associated with older driver crashes. These campaigns often target multiple segment populations, including the older drivers themselves as well as family, friends, or other concerned individuals that are in a position to address a high risk older driver.

Table 7 contains a list of the countermeasures reviewed herein and an estimate of each countermeasure's effectiveness, cost, and issues for implementation. The ratings follow the system previously described.

Table 7. Estimates of each older driver countermeasure for effectiveness, cost, and implementation issues.

Countermeasure	Effectiveness	Cost	Implementation Issues
Courses for Older Drivers	Medium	Low	Low
Communications and Outreach Programs	Low	Medium	Low
License Screening & Testing	High	Medium	Medium
Engineering Countermeasures	Medium	Medium to High	Medium

COURSES FOR OLDER DRIVERS

Effectiveness: Medium **Cost**: Low **Implementation** Issues: Low

Overview

A number of driver retraining courses are offered by a number of different organizations including, but not limited to, AAA's "Safe Driving for Mature Operators", AARP's "Driver Safety Program", and the National Safety Council's "Coaching the Mature Driver Program." The most popular of the courses is AARP's Driver Safety Program.

While the content of the courses may vary, they typically consist of 6-10 hours of classroom instruction spaced over multiple sessions. They cover a number of topics including traffic laws and regulations, the effects of aging on the skills needed to drive, discussions of special situations that cause problems for older drivers, and defensive driving skills.

A rare few courses offer on-road retraining as well. In the State of Michigan, the Traffic Improvement Association of Oakland County provided a program simply called a "Driver Refresher Workshop" designed to help mature drivers (drivers 55 or older) evaluate their driving skills and learn how to drive with the changes in their physical, cognitive, and perceptual abilities. The program consists of two four-hour sessions over two days that focus on similar topics as those mentioned above. On the third day, students in the class can participate in an on-road evaluation of their driving. It is important to note that the students are not judged during this session; it is simply used as a method to provide detailed feedback and to enhance self-awareness outside of the classroom.

Effectiveness

Research has repeatedly shown that taking an education focused driver retraining course (without any on-road instruction) can lead to significant improvement in driver behavior, but that there is no effect on the number of crashes that older drivers are involved in (Janke, 1994; Kua et al., 2007; NCHRP, 2004). Other research has shown that the addition of an on-road training component can lead to improvements in driving performance (Korner-Bitensky, Kua, von Zweck, and Van Benthem, 2009; Romoser and Fisher; 2009). No research has been conducted yet that shows significant changes in crash rates as a result of such retraining.

Cost

The costs are typically low (e.g., the Traffic Improvement Association of Oakland County Driver Refresher Workshop costs $20). Occasionally, individuals can procure funding through other organizations or receive discounts on their auto insurance to compensate for the cost.

Implementation Issues

Courses are already offered regularly. If changes to a program are desired, there would be time needed to integrate the changes.

COMMUNICATION AND OUTREACH PROGRAMS

Effectiveness: Low **Cost**: Medium **Implementation Issues**: Low

Overview

Organizations (e.g., AAAFTS, AARP, NHTSA) have been conducting communications and outreach programs that address older driver safety for years. While the specific goals of each campaign can vary, in general, the ultimate objective of each campaign is to aid older drivers, their friends and family, and concerned citizens in their attempt to retain the independence that driving provides while also maintaining safety for themselves, their passengers, and other road users.

Two examples of older driver safety campaigns include The AAA Foundation's "Drivers 65 Plus: Test Your Own Performance" and the AARP's "The Older Driver Skill Assessment and Resource Guide: Creating Mobility Choices." Both programs serve as self-assessment tools for older drivers. They have been developed and implemented under the belief that knowledge and self-awareness can help someone make better informed decisions about when to get behind the wheel and when to seek other forms of transportation.

The AAAFTS's Drivers 65 Plus tool is a self-rating form that contains 15 questions aimed at helping the driver examine his/her own ability to keep driving safely. After completing the assessment, the driver is referred to a rating guide where they can calculate a score and identify their driving strengths and weaknesses. The driver is then instructed to read a section containing a number of suggestions for improvement that relate to the questions posed in the self-assessment. The tool can be found at http://www.seniordrivers.org/driving/pdf/driver65.pdf. AARP's tools are very similar in nature.

Examples of other materials (which may not necessarily contain self-assessment tools) include:

- Roadwise Review: a free screening tool developed by AAA to help seniors measure certain mental and physical abilities important for safe driving. (http://www.seniordrivers.org/driving/driving.cfm?button=roadwiseonline)
- The "Drive Well" program developed collaboratively between NHTSA and the American Society on Aging. (http://www.nhtsa.gov/DOT/NHTSA/Traffic%20Injury%20Control/Articles/Associated%20Files/DriveWellTK.pdf)
- The "Physician's Guide to Assessing and Counseling Older Drivers' developed collaboratively between the American Medical Association, NHTSA, and the U.S. DOT. (http://www.ama-assn.org/ama/pub/physician-resources/public-health/promoting-healthy-lifestyles/geriatric-health/older-driver-safety/assessing-counseling-older-drivers.page)

- The State of California's "Senior Guide for Safe Driving." (http://dmv.ca.gov/pubs/dl625/dl625senior.pdf)
- Florida Senior Safety Resource Center online survey. (http://fssrc.phhp.ufl.edu/assessQuestion.php)
- American Medical Association self assessment. (http://www.ama-assn.org/ama1/pub/upload/mm/433/appendixb.pdf)
- American Association of Family Practice Physicians, "Decisions About Driving" tool kit: https://secure.aafp.org/catalog/viewItem.do?number=978

Michigan has developed a guide for older drivers and their families titled "Driving for Life: A Guide for Older Drivers and their Families." The purpose of the guide is to educate older drivers and their families about the issues older drivers face, how to spot markers for increased risk, and provide tips on how older drivers can manage their limitations and "retain the independence that comes with driving, while limiting the risks to yourself and others." The guide is online at **http://www.michigan.gov/documents/Older_Driver2_38985_7.pdf**. In addition to providing the above mentioned information, it also details the referral process, the steps taken during reexamination, and the State's role in the entire process.

Another program implemented in the State of Michigan developed by the Partnership for Family Safety, a cooperative effort involving the Michigan State Police, Meijer Stores and the Michigan Academy of Family Physicians (MAPF), included the development and distribution of a brochure entitled, "How's My Driving? Simple Tips for Maintaining Driving Skills." The brochure primarily presented information on the importance of maintaining physical fitness as a driver and included tips on how to safely cope with a decline in vision. It also served as resource for older drivers to access information on refresher courses for older drivers and driving self-assessment tools. Free copies of the brochure were made available at Meijer pharmacies and physicians offices who were members of the MAPF. An electronic version is available at http://www.michigan.gov/documents/ElderlyDriving_0909_84709_7.pdf

Other programs have been implemented in Pennsylvania, Oregon, Illinois, and Maryland, to name a few.

Effectiveness

Unfortunately, no evaluations on the effectiveness of older driver safety campaigns specifically have been completed. However, research on campaigns in other driver behavior problems areas indicates that such programs are minimally effective unless the campaign is multi-faceted (i.e., multiple mediums are used to communicate to the general public) and extensive (i.e., a significant amount of time and money has to be invested to insure the message is communicated well to the general public; Williams 2007).

However, regarding the effectiveness of self-assessment tools, Eby et al (2000) found that the completion of a self assessment tool does increase self awareness of one's own driving skill.

Cost

The costs for a program can vary greatly. Development of many of the materials that would be used has already been completed; unless a decision is made to customize or develop additional materials, the cost is negligible. The costs can increase significantly though the larger the program is. The addition of advertising on radio and television can increase costs significantly.

Implementation Issues

Other organizations are willing to develop these types of programs and execute the campaigns at a national level as well as provide the materials for free access in the public domain. Often, they are simply toolkits that states and other entities need to apply. However, if customization of materials or further development is desired, then the time to implement can increase significantly.

LICENSE SCREENING AND TESTING

Effectiveness: High **Cost**: Medium **Implementation Issues**: Medium

Overview

In 2003, NHTSA published a report titled "Model Driver Screening and Evaluation Program, Volume II: Maryland Pilot Older Driver Study. In the report they detailed:

- A driver screening program that was developed for identifying drivers who posed a safety risk to themselves, their passengers, and the general public when they operated a vehicle.
- Measures that can be taken to address the issues that are the root cause of the dangers.
- Methods to help drivers who are in need of alternative means of transportation.
- An education program for the general public and professionals that discusses the effects of declines in physical, perceptual, and cognitive abilities on driver safety

License screening and testing includes a battery of functional tests that can be administered relatively quickly and inexpensively within licensing agencies to determine older drivers' functional status relative to vision, cognition, and physical movement.

However, recent publications suggest that the Model Program has yet to be picked up at the State level. In fact, recent publications suggest that many State guidelines for license screening, particularly of older adults, are outdated and/or incomplete (Carr et al. 2010; Wang et al., 2003). Instead of implementation of the Model Program, other programs have been developed at the State level.

For example, Oregon has developed a program for medically at-risk individuals (http://www.oregon.gov/ODOT/DMV/ATRISK/index.shtml), which undoubtedly would include a large percentage of older drivers. The mission of the program is to "preserve the independence, dignity and self-esteem that results from providing one's own mobility, so long as it is possible to do so without risk to oneself or others." The Oregon Department of Motor Vehicles (DMV) requires that certain physicians and health care providers report drivers with severe functional or cognitive impairments that cannot be corrected or controlled by surgery, medication, therapy or a driving device or technique. Drivers can also voluntarily report themselves to take part in the program. After reporting, drivers are screened to determine the level of functional and cognitive impairments and a course of action is recommended. If that is retraining, then the program has a suite of materials including brochures, training videos, etc. that can be provided to the driver.

In Michigan, the Drive-Ability Program has been implemented to provide comprehensive clinical driving evaluations and recommendations based on a person's needs and abilities. Individual evaluations are offered by trained occupational therapist after they are referred by a

physician. The driver is then put through a series of evaluations including a review of their medical and driving history, visual and perceptual assessment, physical abilities' evaluation, cognitive testing, and driving knowledge tests. Recommendations regarding further testing or for participation in a driver reeducation program are then made.

Similar programs have been test or implemented in Utah, Pennsylvania, Virginia, Massachusetts, Florida, and Ohio, to name a few.

Effectiveness

Some studies support the notion that screening of older drivers can provide insight into the risks to older drivers. For example, Edwards et al (2008) found that older drivers with a history of vehicle crashes who were screened for fitness to drive performed worse than both younger drivers and older drivers who did not have a history of vehicle crashes. In contrast, other studies have shown that there is no benefit to screening for fitness to drive. For example, Langford et al. (2004) compared the crash rates of drivers 80 years old or older in one metropolitan area where there is not mandatory assessment (Melbourne, Australia) to a second metropolitan area where there is mandatory assessment (Sydney, Australia). Their findings suggested that mandatory license re-testing schemes of the type evaluated have no demonstrable road safety benefits overall.

It is important to note that the screening programs can vary significantly, from when and how drivers are referred to the program to the actual tests used to determine fitness to drive. In order for a screening program to be effective, Molnar et al. (2007) listed the following components as important to develop as part of the program:

- Strong legislation for accelerated or in-person license renewal
- Greater reporting by physicians and other professionals where needed
- Clear information for physicians on reporting requirements and procedures
- Strong and active medical review boards
- Clear and objective guidelines and adequate training
- Valid, reliable, and efficient screening procedures

Cost

Development of screening programs can be time consuming and expensive. However, they are often relatively cheap for the driver being tested.

Implementation Issues

Given the components listed by Molnar et al. (2007) necessary for an effective screening program, implementation issues of a new or changes to an existing program could be significant.

ENGINEERING APPROACHES

Effectiveness: Medium **Cost**: Medium to High **Implementation Issues**: Medium

Overview

Engineering approaches to accommodate highway infrastructure to meet the capabilities and limitations of an older driver segment have the collateral benefit of also addressing needs of the general population. Drivers in other age segments often suffer some of the same limitations in physical, perceptual and cognitive abilities as the older driver segment. They no doubt would benefit from an increased push in implementing engineering approaches designed to aid older drivers. Also, as previously described at the beginning of the section, the percentage of persons 65 years and older is projected to increase to 19% by 2030, and the total number of persons 65 years and older is projected to more than double by 2050 to 88.5 million. Thus, the integration of engineering countermeasures will benefit a larger number of older drivers and a larger percentage of the general population as time passes.

For a comprehensive review of various engineering countermeasures the reader is referred to two documents:

- FHWA. (2001). Highway Design Handbook for Older Drivers and Pedestrians. Washington, DC: Federal Highway Administration. www.fhwa.dot.gov/publications/research/safety/humanfac/01103/
- NCHRP, Vol 9. (2004). *A Guide for Reducing Collisions Involving Older Drivers.* Washington, DC: Transportation Research Board. onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_500v9.pdf

The countermeasures reviewed in the reports include offset left-turn lanes, street name signing, traffic signals, roundabouts, advance warning signs, and advanced guide signs, to name a few.

Effectiveness

The effectiveness of many engineering approaches is not yet determined. However, FHWA (2009) recently completed an evaluation of safety benefits of advance street name signs. They found that advance street name signs have a minimal effect on the total number of crashes at signalized intersections regardless if they were rear-end, older driver, or injury-related crashes. However, the approach has the potential to reduce crashes significantly at roads with three-legged intersections or at locations with large amounts of average daily traffic or expected crashes. The signs were also effective for reducing sideswipe crashes within 750 feet of signalized intersections. In the same study, offset left turn lanes were shown to have significant potential to reduce crashes and crash severity at signalized intersections (up to 34% in total crashes compared to current left turn methods).

Cost

The costs associated with the implementation of many of these approaches can vary.

Implementation Issues

Some of the engineering countermeasures discussed in the reports detailed above will be difficult to implement because of the costs and labor associated with them.

In order for the implementation of engineering countermeasures to be effective, Molnar et al (2007) listed the following components as important to develop as part of the program:

- Design guidelines responsive to needs of older drivers
- Uniform guidelines across jurisdictions
- Adequate training and resources for effective implementation
- Demonstrated safety and cost effectiveness
- Efforts in place to educate older adults about roadway improvements

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OTHER INNOVATIVE SOLUTIONS

The purpose of this section is to present countermeasures that are either relatively new or do not fall specifically into one of the driver behavior problem areas previously addressed. The structure of the reviews and their ratings are the same as in the previous sections.

Table of Summary Ratings. Table 8 contains a list of the countermeasures reviewed herein and an estimate of each countermeasure's effectiveness, cost, and issues for implementation. The ratings follow the system previously described.

Table 8. Estimates of each innovative countermeasure solution for effectiveness, cost, and implementation issues.

Countermeasure	Effectiveness	Cost	Implementation Issues
Passive Speed Control Devices	High	Low	Low
Thermal Surface Displays	Medium	Medium	Low
HAWK Pedestrian Intersections	High	High	Medium

PASSIVE SPEED CONTROL DEVICES

Effectiveness: High **Cost**: Low **Implementation Issues**: Low

Overview

Passive speed control devices change the visual information processed by drivers in an attempt to influence driving behavior. For example, markings (e.g., painted chevrons, transverse lines) can be added to the road that distort perception and create the illusion to drivers that they are going faster. The objective of such a design is to encourage drivers to slow down by making them feel like they are speeding up. The markings are typically placed on the road so that the spacing of the markings is continuously decreased in the direction of travel. In addition, the width of the markings may decrease as well. The two manipulations communicate to the driver that they are traveling faster since if speed was to really increase, more markings would pass by in a given period of time and the time it took for each marking to pass by would reduce as well.

Effectiveness

Research has shown that a driver's speed can be influenced simply by strategically painting road markings in the driving environment. Meyer (2001) was able to demonstrate that horizontal bars placed before a construction work zone that varied in width and spacing induced reductions in speed, indicating the existence of perceptual effects. Other studies have also shown that the implementation of such road markings could lead to a reduction in the incidence of speeding in construction zones (or in other areas where speed reductions are needed). Crashes reductions can range anywhere from 20% to 71% when chevrons are installed (Agent, Stamatiadas, and Jones, 1996).

Finally, research has also shown that markings do not necessarily have to be placed on the roadway itself to have an effect on vehicle speed. In a study by Manser and Hancock (2007), passive speed control markings (i.e., vertical bars) were placed on the interior of a simulated tunnel wall (see Figure 11).

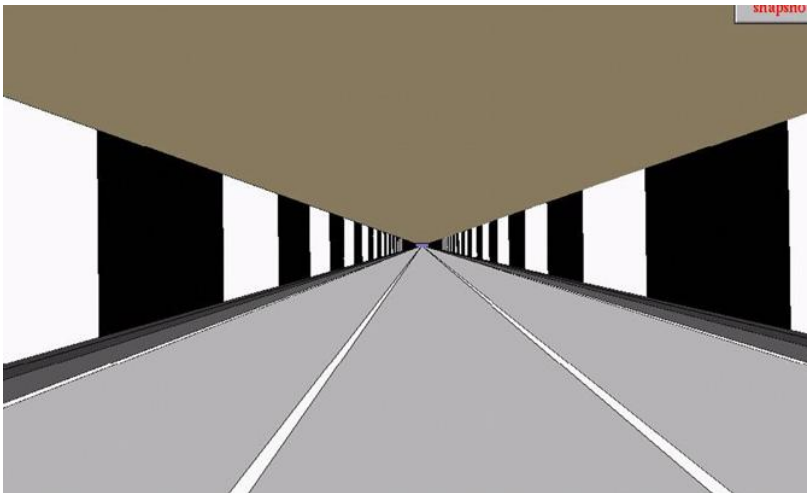

Figure 11. Vertical bars in a simulated tunnel wall.
Source: Manser & Hancock (2007)

As drivers drove through the tunnel, spacing between the markings decreased and the width of the markings decreased. They found that implementing the passive speed control device did significantly reduce driver speed as they traveled through the tunnel.

Costs

The cost can vary depending on the type of paint used, but in general, the installation costs of road markings are low.

Implementation Issues

Painted road markings have been use frequently, thus, installation is routine and they are common to the general public.

THERMAL SURFACE DISPLAYS

Effectiveness: Medium **Cost**: Medium **Implementation Issues**: Low

Overview

To create a thermal surface display, a color indicative sheet or device that is temperature sensitive is bonded to a surface like the roadway or a traffic sign. The surface changes colors as the temperature lowers, and can be used to communicate to drivers that a roadway surface may be icy. One example of such a system is the Bluestar System.

The Bluestar System is a set of temperature sensitive reflectors that are intended to be mounted to a series of posts leading up to a bridge (similar to road delineators). When the temperature is above freezing, the reflectors would act as normal delineators. However, when the temperature drops to near freezing or below, the reflective surface changes color (from a gray star to a blue star; see Figure 12).

Figure 12. Change in the BlueStar System display as temperature falls below freezing.

The goal of the system is to change driver behavior by providing real-time data on the likelihood of encountering an icy surface (compared to the more common "Bridge May Be Icy" sign or similar signs seen year round).

Effectiveness

There is no data on the effectiveness of the Bluestar device or similar devices.

Cost

The Bluestar System is sold as safety package for bridge installations and typically costs less than $1,000. The cost of other similar devices is unknown. In addition to installing the Bluestar System, or others like it, a campaign to inform the general public about their installation and

their purpose might want to be considered, which would cost additional money. As a less costly alternative, a sign like that in Figure 13 could be installed.

Figure 17. Sample roadsign with instructions on how to read the Bluestar System display.

Implementation Issues

The Bluestar system is no more difficult to install than regular delineators. Informing the general public about their presence and purpose would take time. The Bluestar System has already been implemented in Calhoun County, Michigan. An issue to investigate before implementation is how the technology accounts for differences in air temperature and road surface temperature.

HAWK PEDESTRIAN SIGNALS

Effectiveness: High **Cost**: High **Implementation Issues**: Medium

Overview

High-intensity Activated crossWalK (HAWK) pedestrian intersections are relatively new intersections that provide multiple cues to a driver about the presence of a pedestrian through a device called the HAWK beacon (two red lenses over a single yellow lens). Extra cues are also provided about the presence of a pedestrian crosswalk itself through the implementation of high-visibility crosswalk markings (ladder-style markings as opposed to only two transverse white lines), a stop bar approximately 50 ft from the crosswalk, 8-inch solid lane lines between through travel lanes, signs that can be illuminated and read "CROSSWALK," and "School Warning" signs (where necessary). A picture of a HAWK intersection can be found in Figure 14.

Figure 14. A HAWK pedestrian intersection
(Source: FHWA, 2010)

Effectiveness

In a study funded by the FHWA (FHWA, 2010), 21 intersections where a HAWK pedestrian intersection has been installed were evaluated. They found that the installation of HAWK pedestrian intersections led to a reduction in both pedestrian and vehicle crashes.

Costs

HAWK pedestrian intersections are estimated to cost between $55,000 and $75,000 each, depending on the varying nature of design.

Implementation Issues

The Michigan Department of Transportation, in cooperation with the city of Ann Arbor, has installed a new HAWK signal at the corner of the I-94 Business Loop (Huron Street) and Third/Chapin Street in downtown Ann Arbor. Implementation is only difficult to the extent that portions of roads need to be closed during installation.

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PILOT STUDY: THE EFFECT OF CONSTRUCTION ZONE DESIGN ON DRIVER BEHAVIOR: A SIMULATOR STUDY

As part of the project, the CMU DEER Center was asked to perform a pilot study of a relatively new and promising behavioral countermeasure. After the research that supported development of the previous section was conducted, a meeting was held between the project sponsors and CMU DEER Center personnel for the purpose of selecting the topic of the pilot study. Based on the uniqueness of the countermeasure (described in more detail below), the capabilities of the CMU DEER Center facilities and equipment, the time and budget constraints, and the interests of the project sponsor, it was decided that a simulator evaluation of a unique passive speed control device application would be tested.

Introduction

In the current study, the CMU DEER Center investigated driving behavior in construction zones and the effects of varying construction zone designs on vehicle speed. This study addresses the overarching objective of developing recommendations for construction zone design that reduce the tendency to increase speed (and promote other safe driving behaviors) as drivers travel through a construction zone. Specifically, the effectiveness of implementing a passive speed control device in a construction zone on speed reduction was investigated. In addition, the effect of construction zone length on speed was also investigated.

Perceptual Speed Regulation as a Passive Speed Control Countermeasure. Visual perception is the most significant source of information for the driver; therefore, manipulations of the visual information processed by drivers could lead to changes in driver behaviors such as the maintenance of vehicle speed (Sivak, 1996, Manser and Hancock, 2007). In fact, the manipulation of visual information for the purposes of affecting the maintenance of vehicle speed has already been implemented in the form of passive speed control devices. For example, markings (e.g., painted chevrons, transverse lines) can be added to the road that distort perception and create the illusion to drivers that they are going faster than they are. The objective of such a design is to encourage drivers to slow down by making them feel like they are speeding up. The markings are typically placed on the road so that the spacing of the markings is continuously decreased in the direction of travel. In addition, the width of the markings may decrease as well. The two manipulations communicate to the driver that they are traveling faster than they are because if their speed really was to increase, more markings would pass by in a given period of time and the time it took for each marking to pass by would be reduced.

Research has shown that a driver's speed can be influenced by strategically painting road markings in the driving environment. Meyer (2001) was able to demonstrate that horizontal bars placed before a construction work zone that varied in width and spacing induced reductions in speed, indicating the existence of perceptual effects. Other studies have also shown that the

implementation of such road markings could lead to a reduction in the incidence of speeding in construction zones (or in other areas where speed reductions are needed). Crash reductions can range anywhere from 20% to 71% when chevrons are installed (Agent, Stamatiadas, and Jones, 1996).

In the innovative solutions section we reviewed the concept of passive speed control devices. A passive speed control device changes the visual information processed by drivers in an attempt to influence driving behavior (e.g., speed). Typically, when one thinks of a passive speed control device, transverse lines, chevrons, or other painted road markings come to mind. However, in the innovative solutions section we reviewed a study by Manser and Hancock (2007) in which they tested the effect of the placement of vertical lines in a simulated tunnel on speed maintenance. They found that manipulating the spacing and width of the vertical lines did have an effect on speed maintenance. Thus, research has also shown that markings do not necessarily have to be placed on the roadway itself to have an effect on vehicle speed.

In this study, we tested a similar concept; the manipulation of the spacing between barrels in a construction zone. Specifically, we aimed to determine if gradually reducing the spacing of barrels in construction zone would have an effect on speed maintenance (specifically, would it cause drivers to slow down?).

The Effect of Construction Zone Length on Driver Speed. Research has shown that there is a tendency for drivers to speed up in a construction zone as they travel through it (i.e., from the time they enter the construction to the point where they reach construction equipment and crew), particularly if the presence of road crew or construction equipment is farther away from the beginning of the construction zone than drivers expect. (It is important to note that in this study we have referred to the term "construction zone" to refer to any area in which barrels are used to manipulate traffic, while "work zone" is used to refer to the area in which equipment or crew are located.) For example, Indiana found that a reduced speed limit implemented when workers were present was not obeyed for the entire length of a work zone when work was occurring in only a small section of the work zone[7]. Thus, the current study was also designed so that further insight could be gained into that phenomenon. Specifically, will speed change as the length of the construction zone that does not contain crew or equipment increases?

[7] Source: FHWA Work Zone Safety and Mobility Program Best Practices website, http://ops.fhwa.dot.gov/wz/practices/best/view_document.asp?ID=150&from=crossref&Category_ID=18

Methods

Subjects. Twenty subjects participated in the study. The mean age of the subjects was 30.8 years (SD =5.7). Twelve subjects were female and 8 were male. All subjects had 20/20 vision or had vision corrected to 20/20 (e.g., through contacts or prescription glasses).

Instrumentation. Data were collected using the Central Michigan University's AAA Michigan Driving Simulator. The simulator is a DriveSafety DS-600c driving simulator (DriveSafety Corporation). The simulator provides a 180 degree forward field of view driving scenario. Side-view and rear-view mirrors are implemented as LCD displays. The simulator is equipped with a 1.5 degree-of-freedom motion base which provides motion cues in pitch with minimal forward/reverse translation. The cab of the simulator is the forward passenger cabin of a compact car (see Figure 15).

Figure 15. The DEER Center's AAA Michigan Driving Simulator

Tasks. Subjects drove through six driving simulation scenarios; one practice scenario and five experimental scenarios. The following features were common across all six scenarios. All drives were on a straight, 6-lane highway (3 lanes in each direction) with a speed limit of 70 miles per hour (mph) during daylight conditions. Subjects were instructed to follow the speed limit and drive in the far right lane. In all six scenarios, the right two lanes were eventually closed due to construction, leaving only a single open lane on the left side of the 3-lane roadway.

The taper (the gradual closing of the right two lanes) leading into the construction zone began 6000 feet after the beginning of the drive[8]. The taper spanned the two right lanes and was 1440

[8] In the current study, the construction zone refers to the distance between the end of the taper and the presence of the construction crew and equipment.

feet in length leading up to the construction zone. All scenarios were the same from the beginning of the run to the end of the taper (see Figure 16). In addition, all scenarios contained a construction crew and equipment which were placed 500 feet before the end of the run[9]. Finally, no other traffic was present on the road during the experiment. It was not until after the end of the taper that any experimental manipulations were implemented.

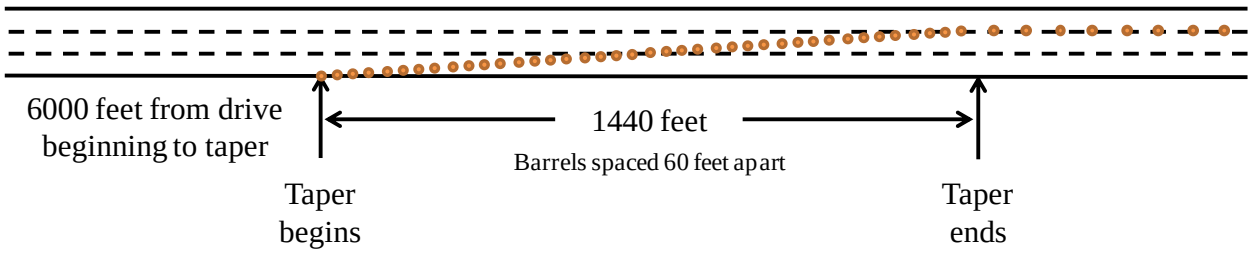

Figure 16. Dimensions of the taper leading into the construction zone.

Barrel Reduction Scenarios. To investigate the effect of barrel spacing on speed, two scenarios with different spacing patterns between the barrels were created. In one scenario, the barrels were initially spaced 120 feet apart (starting at the end of the taper) and then were reduced by 5 feet approximately every 500 feet starting at 2500 feet after the end of the taper (see upper panel Figure 17; from herein this will be referred to as the gradual scenario). In a second scenario, the barrels were initially spaced 130 feet apart (starting at the end of the taper) and then were reduced by 10 feet approximately every 500 feet starting at 2500 feet after the end of the taper (see lower panel in Figure 17). In other words, the rate of change in barrel spacing was faster and more dramatic than the gradual scenario (from herein this will be referred to as the rapid scenario). For both barrel spacing scenarios, the lengths between the end of the taper and first piece of construction equipment was 5500 feet.

[9] In the current study, this zone will be called the work zone.

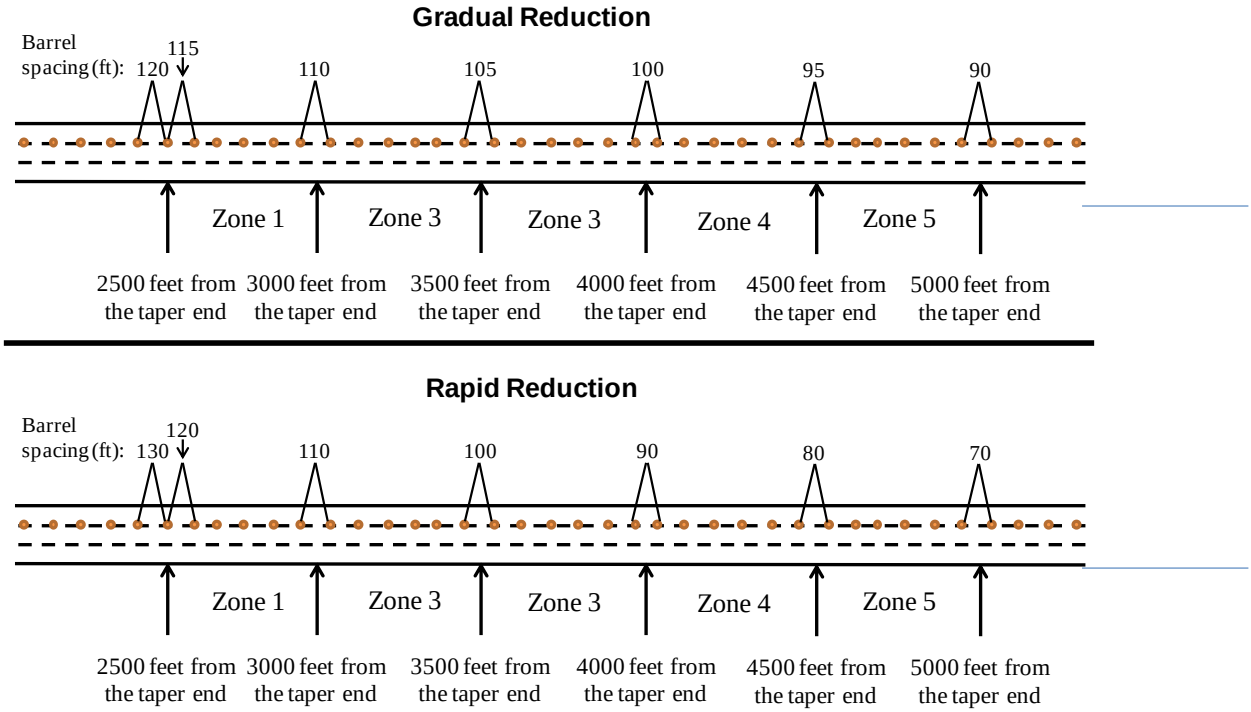

Figure 17. The barrel spacing manipulations. The gradual reduction manipulation is presented in the upper panel. The rapid reduction manipulation is presented in the lower panel. The reduction in barrel spacing in each manipulation occurs five times, creating five different zones in which barrel spacing has been reduced. The change in the barrel spacing is noted at the beginning of each zone. The space between each pair of barrels is maintained until the beginning of the next zone, at which point the space reduces again (by 5 feet for the gradual-reduction manipulation and 10 feet for the rapid-reduction manipulation).

Construction Zone Length Scenarios. To investigate the effect of construction zone length closure on speed, three scenarios with varying lengths between the end of the taper and the work zone were created (i.e., the length of the construction zone varied). In one scenario the length of the construction zone prior to the work zone was 500 feet (and will from herein be referred to as the short scenario). The length between the construction zone and the work zone in the other two scenarios were 3000 feet (and will from herein be referred to as the medium scenario) and 5500 feet (and will from herein be referred to as the long scenario, see Figure 18). The barrels in these scenarios were always spaced 120 feet apart; there was no manipulation of the spacing between the barrels.

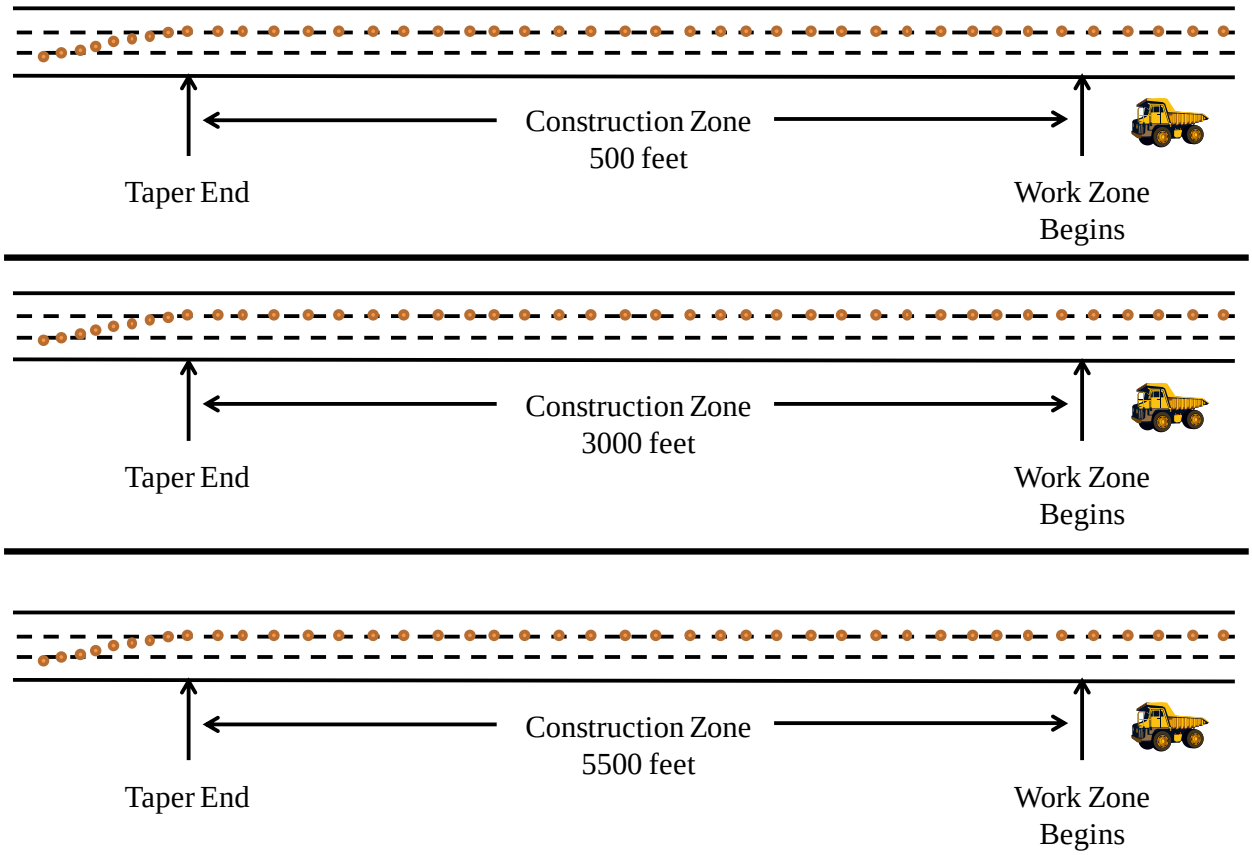

Figure 18. The construction zone length manipulation. The short construction zone scenario is in the top panel. The medium construction scenario is in the middle panel. The long construction zone scenario is in the bottom panel.

Procedure. The pilot study was approved by the CMU Institutional Review Board. Upon arrival, subjects completed a consent form (see Appendix B) and a biographical form (see Appendix C). After completing the forms subjects were placed into the simulator and allowed to adjust the seat for their comfort.

All subjects participated in a practice scenario first. The practice scenario was a single run through a construction zone 5500 ft in length. The construction zone length scenarios and the barrel spacing scenarios were treated as blocks of conditions. Half of the subjects performed a block containing the three construction zone length scenarios first while the other half performed a block with the two barrel spacing scenarios first. In addition to balancing the order of the blocks, the scenarios were balanced within each block (i.e. order of the construction zone length scenarios was balanced, as well as the order of the barrel spacing scenarios). After completing the last scenario, subjects were debriefed.

Measures and Analyses. Mean velocity and the standard deviation of velocity were the primary measures calculated. The effect of the road length and the barrel spacing manipulations were determined by comparing the mean velocity and standard deviation of velocity for five sequential zones presented in Figure 17 (each approximately 500 ft. in length) across the course of the three runs that were 5500 ft. in length (i.e., the long construction zone length condition, the gradual reduction condition, and the rapid reduction condition). In addition to comparing the measures for the gradual and rapid reduction conditions, the long construction zone length condition was included in the analysis to serve as a baseline condition in which the barrel spacing remained 120 ft throughout the length of the construction zone was included in the analysis.

Results

SPSS for Windows (ver. 17.0) was used for all analyses. Analysis of Variance (ANOVA) was conducted to 1) determine if there was an effect of varying barrel spacing on the mean velocity and standard deviation of velocity, and 2) determine if there was a significant effect of construction zone length on velocity.

Barrel Spacing. A 3 (condition: baseline, gradual, rapid) x 5 (zones 1-5) repeated measures ANOVA revealed that the mean velocity was significantly different for the factors of condition, $F(2, 34) = 8.535$, $p < .001$, and zone $F(4, 68) = 37.378$, $p < .001$. Mean velocity was significantly different between the three conditions (baseline = 58.3mph, rapid = 57.9mph, and gradual = 55.5mph). Mean velocity decreased significantly from zone 1 to zone 5 (zone 1 = 59.5mph, zone 2 = 59.2mph, zone 3 = 58.4mph, zone 4 = 56.5mph, zone 5 = 52.6mph). The interaction between condition and zone was also significant, $F(8, 136) = 3.709$, $p < .01$, indicating that the rate of decrease in velocity from zone 1 to zone 5 was different for the three different conditions. Figure 19 illustrates the differences in mean velocity between the baseline, gradual, and rapid barrel spacing conditions and across the 5 zones.

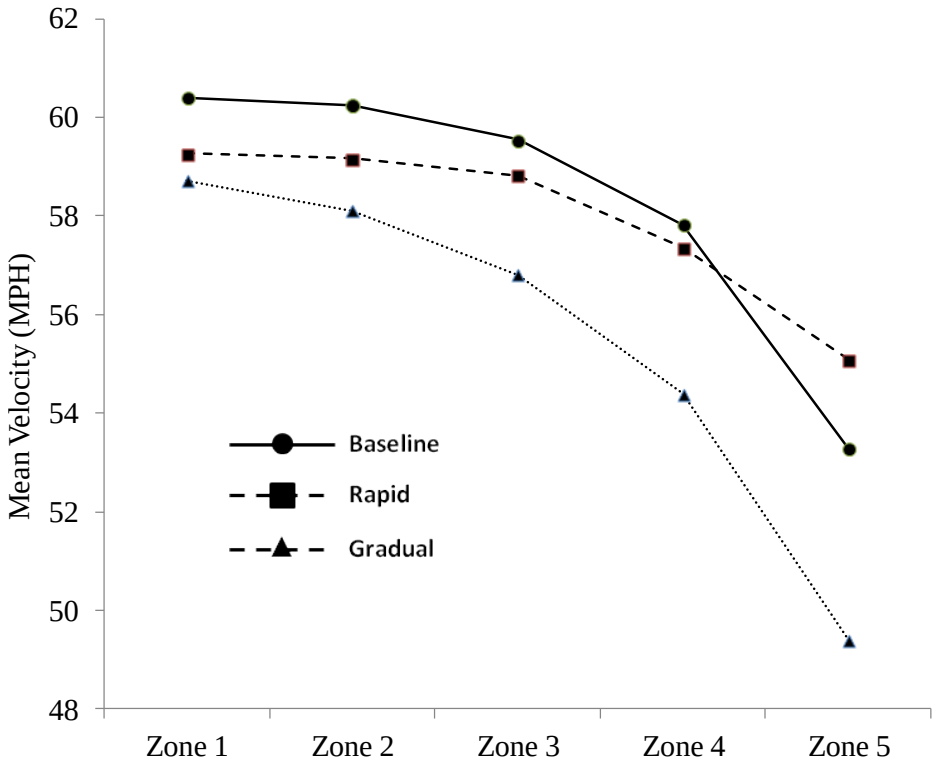

Figure 19. Mean velocity as a function of the spacing between barrels. The zones represent a 500 foot section with the barrel spacing for each zone labeled on the graph. The baseline barrel spacing condition is represented by the solid line and circle (●) The rapid barrel spacing condition is represented by the dashed line and square (■) markers. The gradual barrel spacing condition is represented by the dotted line and triangle (▲) markers.

Because each of the previous analyses were significant, comparisons between each pair of conditions were made to further assess differences in effects of the barrel spacing manipulations. First, analyses were conducted to see if the gradual barrel spacing condition was different than the rapid barrel spacing condition. A 2 (condition: gradual, rapid) x 5 (zones 1-5) repeated measures ANOVA revealed that the mean velocity was significantly different for the factors of condition, $F(1, 17) = 12.215$, $p < .01$, and zone $F(4, 68) = 31.095$, $p < .001$. Mean velocity was significantly different between the gradual and rapid conditions (gradual = 55.5mph and rapid = 57.9mph). Mean velocity decreased significantly from zone 1 to zone 5 (zone 1 = 59.0mph, zone 2 = 58.6mph, zone 3 = 57.8mph, zone 4 = 55.9mph, zone 5 = 52.2mph). The interaction between condition and zone was also significant, $F(4, 68) = 7.870$, $p < .01$, indicating that the rate of decrease in velocity from zone 1 to zone 5 was different for between the gradual and rapid conditions. Figure 19 illustrates the differences in mean velocity between the gradual and rapid barrel spacing condition and across the 5 zones.

Second, analyses were conducted to see if the baseline barrel spacing condition was different than the gradual barrel spacing condition. A 2 (condition: baseline, gradual) x 5 (zones 1-5) repeated measures ANOVA revealed that mean speed was significantly different for the factor of condition $F(1, 17) = 10.531$, $p < .01$, and zones, $F(4, 68) = 40.245$, $p < .001$. Mean velocity was significantly different between the gradual and rapid conditions (baseline = 58.2mph and gradual = 55.5mph). Mean velocity decreased significantly from zone 1 to zone 5 (zone 1 = 59.6mph, zone 2 = 59.2mph, zone 3 = 58.2mph, zone 4 = 56.1mph, zone 5 = 51.3mph). There was not a significant interaction between condition and zone, $p = .718$. Figure 19 illustrates the differences in mean velocity between the baseline and gradual barrel spacing condition and across the 5 zones.

Finally, analyses were conducted to see if the baseline barrel spacing condition was different than the rapid barrel spacing condition. A 2 (condition: baseline, rapid) x 5 (zones 1-5) repeated measures ANOVA revealed that mean velocity was significantly different for the factor of zone, $F(4, 68) = 21.978$, $p < .001$. Mean velocity decreased significantly from zone 1 to zone 5 (zone 1 = 59.8mph, zone 2 = 59.7mph, zone 3 = 59.2mph, zone 4 = 57.6mph, zone 5 = 54.2mph). The interaction between condition and zone was also significant, $F(4, 68) = 5.020$, $p < .01$, indicating that the rate of decrease in velocity from zone 1 to zone 5 was different for between the baseline and rapid conditions. . Unlike like the previous comparisons, there was not a significant effect of condition on mean velocity, $p = .874$, meaning that the mean velocity between the two conditions was not significantly different. Figure 19 illustrates the differences in mean velocity between the baseline and rapid barrel spacing condition and across the 5 zones.

The significantly lower velocity of travel in the gradual reduction condition suggests that there may be benefits in safety by implementing the gradual reduction method. However, safety would not only be increased if there was a reduction in velocity, but also if there was a reduction in the variation of velocity as drivers go through a construction zone. To address this issue, similar analyses were conducted on the standard deviation of velocity (SD of velocity) to determine if the variability of speed changed throughout the drive through the construction zone.

A 3 (condition: baseline, gradual, rapid) x 5 (zones 1-5) repeated measures ANOVA revealed that the SD of velocity was significantly different for the factors of condition, $F(1, 17) = 9.028$, $p < .001$, and zone $F(4, 68) = 33.821$, $p < .001$. SD of velocity was significantly different between the three conditions (baseline = 0.73mph, gradual = 0.99mph, and rapid = 0.54mph). SD of velocity decreased significantly from zone 1 to zone 5 (zone 1 = 0.26mph, zone 2 = 0.32mph, zone 3 = 0.54mph, zone 4 = 0.88mph, zone 5 = 1.77mph). The interaction between condition and zone was not significant, $p = .433$, indicating that the change in SD of velocity was not dependent the barrel spacing condition. Figure 20 illustrates the differences in the standard deviation of velocity between the baseline, gradual, and rapid barrel spacing conditions and across the 5 zones.

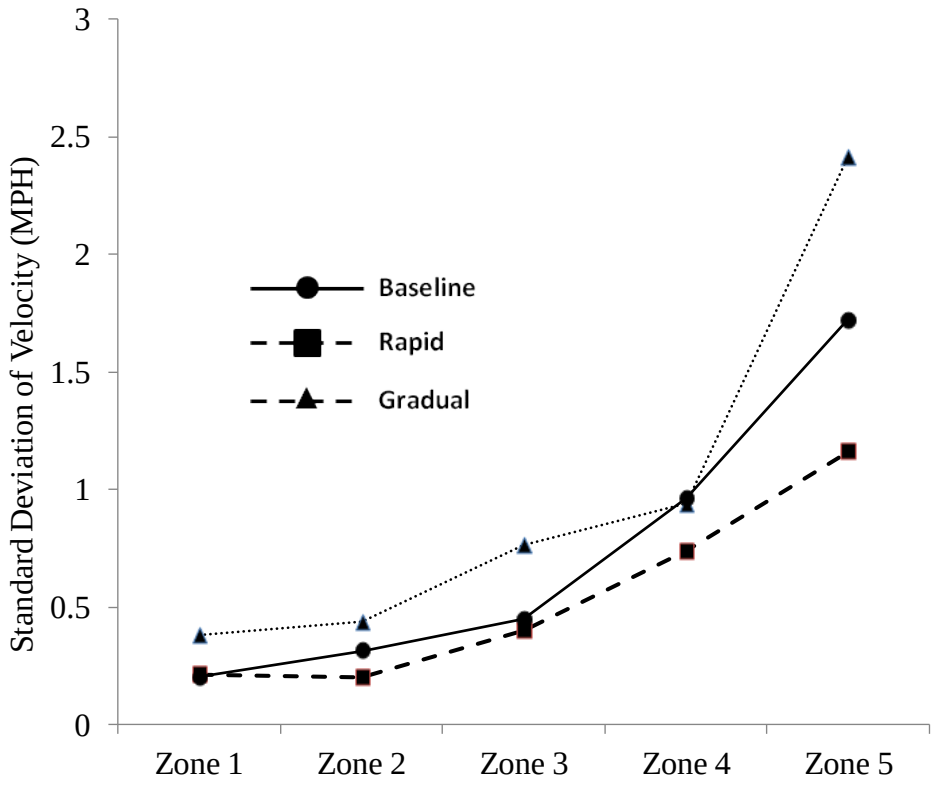

Figure 20. Standard deviation of velocity as a function of the spacing between barrels. The zones represent a 500 foot section with the barrel spacing for each zone labeled on the graph. The baseline barrel spacing condition is represented by the solid line and circle (●) The rapid barrel spacing condition is represented by the dashed line and square (■) markers. The gradual barrel spacing condition is represented by the dotted line and triangle (▲) markers.

Similar to the assessment of mean velocity, comparisons between each pair of conditions were made to further assess differences in effects of the barrel spacing manipulations. First, analyses were conducted to see if the gradual barrel spacing condition was different than the rapid barrel spacing condition. A 2 (condition: gradual, rapid) x 5 (zones 1-5) repeated measures ANOVA revealed that the SD of velocity was significantly different for the factors of condition, $F(1, 17) = 17.952$, $p < .001$, and zone $F(4, 68) = 18.476$, $p < .001$. SD of velocity was significantly different between the two conditions (gradual = 0.99mph, and rapid = 0.54mph). SD of velocity decreased significantly from zone 1 to zone 5 (zone 1 = 0.30mph, zone 2 = 0.32mph, zone 3 = 0.58mph, zone 4 = 0.84mph, zone 5 = 1.79mph). There was not a significant interaction between condition and zone, $p = .113$, indicating that the change in SD of velocity across zones was not dependent the barrel spacing condition. Figure 20 illustrates the differences in the standard

deviation of velocity between the baseline and gradual barrel spacing condition and across the 5 zones.

Second, analyses were conducted to see if the baseline barrel spacing condition was different than the gradual barrel spacing condition. A 2 (condition: baseline, gradual) x 5 (zones 1-5) repeated measures ANOVA revealed that the SD of velocity was significantly different for the factor of zone $F(4, 68) = 22.945$, $p < .001$, but not for condition, $p = .075$. SD of velocity decreased significantly from zone 1 to zone 5 (zone 1 = 0.29mph, zone 2 = 0.37mph, zone 3 = 0.60mph, zone 4 = 0.95mph, zone 5 = 2.07mph). There was no significant difference in SD of velocity between the baseline and gradual conditions. There was not a significant interaction between condition and zone, $p = .759$, indicating that the change in SD of velocity across zoneswas not dependent the barrel spacing condition. Figure 20 illustrates the differences in the standard deviation of velocity between the baseline and gradual barrel spacing condition and across the 5 zones.

Finally, analyses were conducted to see if the baseline barrel spacing condition was different than the rapid barrel spacing condition. A 2 (condition: baseline, rapid) x 5 (zones 1-5) repeated measures ANOVA revealed that the SD of velocity was significantly different for the factor of condition $F(1, 17) = 7.022$, $p < .05$, and zones, $F(4, 68) = 14.315$, $p < .001$. SD of velocity was significantly different between the three conditions (baseline = 0.73mph and rapid = 0.54mph). SD of velocity decreased significantly from zone 1 to zone 5 (zone 1 = 0.21mph, zone 2 = 0.26mph, zone 3 = 0.43mph, zone 4 = 0.85mph, zone 5 = 1.44mph). There was not a significant interaction between condition and zone, $p = .532$, indicating that the change in SD of velocity across zones was not dependent the barrel spacing condition. Figure 20 illustrates the differences in the standard deviation of velocity between the baseline and rapid barrel spacing condition and across the 5 zones.

***Construction Zone Length*.** Analyses were also conducted to see if the length of the distance between two points (the end of the taper entering the construction zone, and the presence of work equipment and people, also called the work zone) has an effect on the mean velocity of travel through the construction zone. A 3 (condition: short, medium, and long) x 2 (point: the end of the taper, the beginning of the work zone) repeated measures ANOVA revealed that the mean velocity was significantly different for the factors of condition, $F(2, 36) = 4.554$, $p < .05$, and point $F(1, 18) = 65.663$, $p < .001$. Mean velocity was significantly different between the three conditions (short = 51.4mph, medium = 52.9mph, and long = 54.0mph). Also, mean velocity decreased significantly from the end of the taper to the beginning of the work zone (end of taper = 57.7mph, beginning of work zone = 47.8mph). However, the interaction between condition and point was not significant, $p = .291$.

Recall that the purpose of this analysis is to determine if a change in the velocity of travel as people drive through the construction zone depends on the length of the construction zone. The lack of an interaction suggests that it does not. Therefore, further paired analyses comparing the conditions to each other are unnecessary and have not been conducted.

Discussion

The study demonstrated that through the manipulation of spacing barrels in a construction zone, a driver can be influenced to slow down. Specifically, it was found that a slow gradual reduction of the spacing between the barrels caused greater reductions in velocity than a more rapid reduction in the space between the barrels.

At first glance, this may seem to be the opposite of what might be expected. One may think that a more "dramatic" effect, which the more rapid reduction may be perceived as being, would have a greater influence on a reduction in speed. However, we believe that the current application of a more rapid reduction was so dramatic that it may have been noticed by the drivers.

One of the inherent advantages of passive speed control devices is that they can change behavior without the driver being aware of their purpose. In fact, we believe that it may be the case that being aware of a passive speed control device's presence may detract from its effectiveness. Thus, when designing a passive control device, consideration must be given to finding that point between not being rapid enough and thereby not inducing the desired effect, and being too rapid and detracting from its effectiveness because drivers become aware of its presence.

However, it is important to note that simply reducing the speed of drivers who may be travelling too fast through a construction zone may not be sufficient. In order to achieve optimal safety and traffic flow levels traffic engineers target posted speeds that are the most common in a given driving environment. This method is used so that as many drivers as possible will be travelling the same speed, with the result being optimized traffic flow and increased safety. With this in mind, we also conducted analyses aimed to assess the variability in speed through the construction zone as a function of the barrel spacing manipulations. Interestingly, we found that speed variability was least in the rapid barrel spacing condition, even compared to current methods (i.e., the baseline condition).

Based on the results of this pilot study, it is recommended that the use of a countermeasure that strategically places barrels in a construction zone with the intention of inducing reductions in speed be considered. If the goal is to simply reduce the speed of vehicles travelling through a construction zone, then a more gradual change should be used. However, if the goal is to reduce the variability in vehicle speeds travelling through a construction zone, then a more rapid change should be considered.

Even further, the application of this phenomenon (perceptual speed regulation as a passive control device) may extend beyond barrels in a construction zone. We recommend that future work includes the exploration of other ways the phenomenon can be applied to improve driver safety. In addition, a limitation in the current study is that the barrels were only located on the passenger side of the car. Placement of the barrels on the driver's side of the car could also be addressed. Finally, we also recommend that a field study be conducted to test the effect of the barrel spacing phenomenon in a more realistic environment.

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APPENDIX A: SOBRIETY CHECKPOINT LAWS AS OF SEPTEMBER, 2011

State	Checkpoints Conducted?	Frequency	Legality
Alabama	Yes	Throughout the year	Upheld under federal Constitution
Alaska	No		No state authority
Arizona	Yes	At least once per month	Upheld under federal Constitution
Arkansas	Yes	Weekly	Upheld under state and federal Constitution
California	Yes	2,500+ annually	Upheld under state and federal Constitution
Colorado	Yes	Once or twice a month	Upheld under state and federal Constitution
Connecticut	Yes		Upheld under state Constitution
Delaware	Yes	Monthly January to June; weekly July through December	Upheld under state law and federal Constitution
D.C.	Yes	Once or twice a month	Upheld under federal Constitution
Florida	Yes	Between 15-20 per month	Upheld under federal Constitution
Georgia	Yes	Weekly	Upheld under state and federal Constitution
Hawaii	Yes	Weekly	Authorized by statute
Idaho	No		Illiegal under state law
Illinois	Yes	Several hundred per year	Upheld under federal Constitution
Indiana	Yes		Upheld under state Constitution
Iowa	No		Not permitted - statute authorizing roadblock controls does not authorize sobriety checkpoints
Kansas	Yes	Once or twice a month	Upheld under state law and federal Constitution
Kentucky	Yes	Weekly	Upheld under federal Constitution
Louisiana	Yes		Upheld under state Constitution
Maine	Yes		Upheld under federal Constitution
Maryland	Yes	Weekly	Upheld under state and federal Constitution
Massachusetts	Yes	Year round	Upheld under state and federal Constitution
Michigan	No		Illegal under state Constitution
Minnesota	No		Illegal under state Constitution
Mississippi	Yes	Weekly	Upheld under federal Constitution
Missouri	Yes	Once or twice a month	Upheld under state and federal Constitution
Montana	No		Statute permits only safety spotchecks
Nebraska	Yes	6 - 10 per month	Upheld under state law
Nevada	Yes	Once or twice a month	Authorized by statute
New Hampshire	Yes	Weekly, weather permitting	Authorized by statute (must be judicially approved)
New Jersey	Yes	Once or twice a month	Upheld under state and federal Constitution
New Mexico	Yes		Upheld under state and federal Constitution (law enforcement must follow guidelines)

State	Checkpoints Conducted?	Frequency	Legality
New York	Yes	Weekly	Upheld under federal Constitution
North Carolina	Yes	Weekly	Authorized by statute
North Dakota	Yes		Upheld under state and federal Constitution
Northern Mariana Islands	Yes	Twice a month	
Ohio	Yes	Year round	Upheld under state and federal Constitution
Oklahoma	Yes	Once or twice a month	Upheld under state and federal Constitution
Oregon	No		Illegal under state Constitution
Pennsylvania	Yes	Several hundred per year	Upheld under state and federal Constitution
Rhode Island	No		Illegal under state Constitution
South Carolina	Yes		No state authority
South Dakota	Yes	Weekly	Upheld under state and federal Constitution
Tennessee	Yes	Once or twice a month	Upheld under state and federal Constitution
Texas	No		Illegal under Texas' interpretation of federal Constitution
Utah	Yes	About every other month	Authorized by statute
Vermont	Yes	Weekly	Upheld under state and federal Constitution
Virgin Islands	Yes	Monthly, during national mobilizations, local festivals and carnivals	
Virginia	Yes	Weekly	Upheld under state and federal Constitution
Washington	No		Illegal under state Constitution
West Virginia	Yes	Weekly	Upheld under state and federal Constitution
Wisconsin	No		Prohibited by statute
Wyoming	No		Prohibited by interpretation of roadblock statute

Source: http://www.ghsa.org/html/stateinfo/laws/checkpoint_laws.html

APPENDIX B: PILOT STUDY CONSENT FORM

CMU
CENTRAL MICHIGAN UNIVERSITY

Title of Project: The Effect of Construction Zone Design on Driver Behavior: A Simulator Study

Investigator: Dr. John K. Lenneman — Phone: 517-896-5649
Department: Psychology — Email: lenne1jk@cmich.edu

Investigator: Dr. Richard W. Backs — Phone: 989-774-6497
Department: Psychology — Email: backs1rw@cmich.edu

You are eligible to participate in this research if you consider yourself to generally be in good health and you have normal or corrected vision (20/40 or better). The following information is provided to help you make an informed decision whether or not to participate. If you have any questions, please do not hesitate to ask.

Purpose. The purpose of this experiment is to better understand driving behavior in construction zones.

Procedure. If you decide to participate in this research project, you will be asked to complete a demographic form that will request general information regarding your age, health, and ethnicity. You will then be asked to complete a questionnaire asking you questions regarding your preferences in construction zone design. Finally, you will be asked to participate in a driving simulation. During the driving simulation you will perform a series of driving tasks in simulated construction zones, and driving performance measures will be collected.

Apparatus. This research will be conducted using the AAA Michigan Driving Simulator in the Driver Evaluation, Education, and Research Center. This high-fidelity simulator consists of a cab of an economy-sized automobile mounted on a two degree-of-freedom motion base. It has a 180 x 60 degree of visual angle forward display and LCD rear-view mirrors.

Timetable. The session will take about one hour to complete (including time for breaks). You will be given the opportunity to take breaks when needed.

Risks. Participation risk is minimal; it is no more than you would encounter in your daily life.

Benefits. We don't anticipate any benefits to you directly. However, in a broad sense, the research will benefit society in general by helping to understand how design of a construction zone can influence driving behavior and in particular.

Compensation. CMU students will receive 2 SONA credits per hour for participation. Community members who are not currently CMU students will receive $10.00 per hour for participation. We expect that the study will take 1 hour to complete for a total of $10.00. CMU students have the option of doing an alternative assignment.

In case of emergency. If you experience discomfort or adverse reactions during the experiment you can have the investigator call CMU Public Safety. You may also call the investigator if you have questions or concerns after the experiment.

Confidentiality. The only individuals who will have access to this information are the investigators listed above. This research is funded by Michigan's Department of Transportation (MDOT) and data from the study will be provided to their research staff. Any information obtained during this study that could identify you or implicate you with regard to the illegal use of alcohol will be kept strictly confidential and will not be released outside the lab in an individually identifiable form without prior consent unless required by law. The information may be published in scientific journals or presented at scientific meetings, but your identity will be kept strictly confidential. Should you decide to withdraw, any video recordings or other data collected from you will be destroyed. Paper records will be shredded. Video recordings will be deleted from the computer systems on which they are stored.

Right to refuse or withdraw. You are free to refuse to participate in this research project or to withdraw your consent and discontinue participation in the project at any time without penalty or loss of benefits to which you are otherwise entitled. Your participation will not affect your relationship with the institution(s) involved in this research project. If you withdraw from the study your compensation will be prorated by the half-hour that you participated. If the experimenter is an instructor of one of your classes, note that he will not know who participated in this project and your relationship with him and your performance in the class will not affected by your participation or non-participation.

Conditions of consent. You must be 18 years-of-age or older.

Questions. The investigator will answer any questions about the research, either now or later. If you have any questions later you can contact Dr. John K. Lenneman (517-896-5649), Department of Psychology, Central Michigan University, Mt. Pleasant, MI 48859. If you are not satisfied with the manner in which this study is being conducted, you may report (anonymously if you so choose) any complaints to the Institutional Review Board by calling 989-774-6777, or addressing a letter to the Institutional Review Board, 251 Foust Hall Central Michigan University, Mt. Pleasant, MI 48859.

Your signature below indicates that you have voluntarily decided to participate in this research project as a participant and that you have read and understood the information provided on this form.

_____ _____ _____

Participant's Signature Participant's Printed Name Date

A copy of this form has been given to me._____ Initials

For the researcher - In my judgment, the participant is voluntarily and knowingly giving informed consent to participate in this research project.

_____ _____ _____

Investigator's Signature Investigator's Printed Name Date

APPENDIX C: PILOT STUDY BIOGRAPHICAL QUESTIONNAIRE

CMU
CENTRAL MICHIGAN UNIVERSITY

Biographical Questionnaire

Title of Project: The Effect of Construction Zone Design on Driver Behavior: A Simulator Study

Investigator: Dr. John K. Lenneman — Phone: 517-896-5649
Department: Psychology — Email: lenne1jk@cmich.edu

Investigator: Dr. Richard W. Backs — Phone: 989-774-6497
Department: Psychology — Email: backs1rw@cmich.edu

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1. Your birthdate: _____

2. Your gender: ____ Male ____ Female

3. Please enter the highest level of education completed?

_____ High School _____ Some College _____ Bachelors _____ More

4. Is your vision corrected? Y | N

5. Have you ever been in a driving simulator before? Y | N When and where? _____

6. How many hours per week do you play video games?? _____
